HOW TO MAKE TYPE READABLE

How To Make Type Readable

A Manual for Typographers, Printers and Advertisers

Based on Twelve Years of Research Involving Speed of Reading Tests Given to 33,031 Persons

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HOW TO MAKE TYPE READABLE

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Preface

In 1927, when we undertook to study the relative legibility of italic, all capital and lower case printing, we did not realize the complexities and difficulties that would be involved in an investigation of the whole range of typographical factors influencing speed of reading. Indeed, we had no intention of investigating all such factors. But, as we studied type size, width of line, leading, and style of type face, it became evident that piece-meal studies would be inadequate. Therefore, in spite of the difficulties, we set out to investigate systematically all measurable and important factors. The net result is a fairly comprehensive picture of the relationship between ten typographical factors and legibility.

The need for such a comprehensive and systematic study arises from the lack of an adequate basis in the technical literature for printing practice. Furthermore, writers in this field have overemphasized Roethlein's classical study which unfortunately gives information only about the legibility of printing read at a distance. It is obvious that reading at a distance and ordinary reading are so different that what is true for one need not be, and frequently is not, true for the other.

A careful study of Pyke's excellent summary of the literature, published in 1926, will convince any student of typography that the field is complex and is characterized by mere opinion and unfounded generalizations.

One of the things that makes the kind of study reported in this book fascinating is the frequent flat contradiction

between the "facts" on the one hand and common sense notions, printing practice and widespread theories about "good" typography on the other. This is best illustrated in our own work by our views in regard to line width. Influenced by textbook assertions that line widths in the neighborhood of three inches are far superior to longer or shorter ones, we were amazed to discover that the facts showed that much longer and shorter line widths are read as fast as the recommended three inch line. This will explain why we performed eleven different experiments on line width. Each additional experiment provided more evidence contradictory to our previous belief. This one instance illustrates the need for facts and still more facts in the field of typography to replace the maze of opinions and theories upon which printing practice is now based. For this reason we have preferred to present our findings in the form of a large number of statistical tables of results with a minimum of discussion and theorizing. In other words, we prefer to let the facts speak for themselves.

One of the reasons for the discrepancy between facts and opinions in this field is the amazing flexibility and adaptability of the human eye in its capacity to adjust to a bewildering variety of typographical arrangements. We habitually read small type of newspaper size and then turn to books and magazines printed in larger type and longer line widths without great discomfort. Our studies confirm this.

The above conclusion, however, does not mean that one typographical arrangement is read just as easily and as rapidly as any other. In fact, important differences do exist and the problem of scientific typography is to discover the precise limits of optimal printing arrangements. Our own studies point clearly to the existence of such optimums.

These are summarized in tabular form in the last chapter.

It should be kept in mind that our series of studies is based on a relatively brief speed of reading test requiring 1¾ minutes for the standard and 1¾ minutes for each changed typographical arrangement. This imposes a real limitation on the significance of our findings. We have shown by experiment that a typographical arrangement which is found to be definitely better than another in our brief test, will be even more effective in a longer test. This means that any differences we find are likely to be highly significant. We cannot be so sure, however, that failure to find a difference necessarily means that no difference would exist in a longer reading period. For example, we found that *italic* printing only slightly retards speed of reading. We suspect, however, that eyestrain and fatigue would accompany the reading of italic printing if read for long periods of time. On the other hand, in the majority of instances where we have found little or no difference between two typographical arrangements, we believe no real difference exists and consequently none would be shown in longer tests.

There will be typographical experts who will argue that our studies in regard to such things as size of type, width of line, and leading should have been made for each of a large number of type faces. This is because many printers place undue emphasis on assumed differences between type faces in legibility. There is no proof, however, that type faces in common use are not equally legible. Our own findings show them to be equally legible. For this reason we believe we have been justified in restricting our studies to Scotch Roman and Granjon type faces when investigating type size, etc. Even so, our simplified procedure required some 45 different experiments, each ranging in

number of subjects from 200 to 10,000. A total of 66,062 reading tests were given to 33,031 persons. It would have been prohibitive to have studied a series of typographical arrangements for each of a number of type faces. We would welcome proof that this would be necessary or desirable.

In planning our studies we ascertained, whenever possible, what current printing practice is in regard to a given typographical factor. We then conducted studies to measure the influence of this factor on speed of reading. This was followed by evidence concerning the opinions of readers with respect to apparent legibility. In this way it was possible to determine whether or not current printing practice is in line with the facts of legibility and reader opinions. So far as we know this is the first time that this three-fold approach to typography has been systematically presented.

In presenting our results we have attempted to minimize the problem of methodology and to simplify our presentation. For this reason we have relegated the detailed account and critique of our experimental method to Appendix I.

Some readers will feel that we have not taken sufficient account of other work than our own. In reply, we might point out that when we published technical reports of some phases of our work on typography, we were careful to review the available relevant literature. In the present book, however, we have assumed that the expert in advertising, typography and printing would not be eager to have our presentation complicated by constant reference to a long list of research findings. Since the bulk of previous investigations are seriously deficient or misleading, due to defects in methodology, references to them would not have been

helpful. Nevertheless, we have not completely ignored other work. As a matter of fact, we have made adequate reference to the findings of other workers when their materials seemed to be pertinent. We have also included in our discussions a criticism of the recent work of Luckiesh and Moss. One should keep in mind the fact that an unusually competent and complete review up to 1926 is available in R. L. Pyke's report. In addition, we have included in an appendix a complete bibliography.

In general, we have used the words legibility and readability interchangeably to mean "ease and speed of reading printed material at a natural reading distance." On the other hand, we have recognized the problem of visibility which is perceptibility of printed material. This latter problem is especially important for the advertiser who prepares copy to be read at a distance. Both kinds of results are presented in our discussions although the bulk of our evidence bears only on legibility in the ordinary reading situation.

In spite of the fact that we have minimized the discussion of methodology in presenting our results, nevertheless it may seem to the practical printer that we have stressed unduly the methods by which we have studied each set of facts presented. The practical printer will also be disturbed at our insistence that he must suspend judgment in dealing with a given typographical factor until the evidence for this factor is presented in relation to the influence of other factors operating simultaneously. To these two charges we plead guilty. So far as we can see, no other way of presenting scientific information about typography is adequate. Facts cannot be divorced from the conditions under which they are secured. Furthermore, in studying a series of factors, the scientific attitude requires one to suspend

judgment in regard to any factor until all the evidence concerning it and related factors is available.

From letters of inquiry concerning our earlier studies published in the *Journal of Applied Psychology*, it is clear that a large number of editors, publishers, printers, advertising experts, and students in journalism and advertising typography are vitally interested in the specific problems we have investigated. Accordingly we have presented our findings with their needs and interests in mind. We anticipate that these professional groups will find our report of value in their daily work. Furthermore, there is reason to believe that the results will be incorporated in improved printing practice. In fact, the few studies we have already published have been used in this way by writers of textbooks on the psychology of advertising and by those planning to improve the typographical features of scientific journals, magazines and books.

Teachers of courses dealing with typography, advertising layouts, etc., will naturally turn to our results for a wealth of detailed factual evidence in regard to the legibility of particular printing arrangements. Students working in this field might profitably use our tabular summary of printing recommendations as a basis for critically studying samples of actual or proposed printing. For example, we suggest that a student would profit greatly by judging given pieces of text in terms of the optimal specifications contained in our tabular summary. One student might study fiction magazines, another scientific journals, another textbooks, and another popular fiction books, and so on. In this way the general findings could be applied to the evaluation of current printing practice. Thus the student could familiarize himself with the extent to which scientific principles are being followed.

We are aware that many of our findings run counter to the beliefs of those who deal with problems of printing. In fact, much of our evidence contradicts some of our own preconceived notions. Confidence, however, in the validity of our scientific method forces us to reject our preconceptions and to accept the findings as fact. Therefore, we have not hesitated to draw up specifications for an ideal printed page and to request that the publishers follow these specifications in printing this book.

It is impossible to acknowledge by name the innumerable school and college officials and teachers who permitted us to test their students. Nevertheless, we deeply appreciate the cordial and effective cooperation we received. Specific grateful acknowledgment, however, can be made to the following: the University of Minnesota Graduate School for a series of research grants; the J. B. Lippincott Company, Philadelphia, and the Educational Test Bureau, Minneapolis, for permission to reprint the Chapman-Cook Speed of Reading Test, Forms A and B, for experimental purposes; Dr. R. M. Elliott, Chairman of the Department of Psychology, University of Minnesota, for constant encouragement; Mr. Milton W. DePuy, Head of the University of Minnesota Printing Department, for his cooperation in preparing an innumerable variety of printing forms; Miss Alice Brooker, Research Assistant, for faithful service in carrying out many of the details required in the conduct of our studies; and Miss Evelyn Schultz for typing reports and the manuscript.

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Minneapolis
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How To Make Type Readable

Chapter 1

Speed of Reading and Typography

TYPE designers are now talking about streamline typography. The emphasis thus shifts from the traditional stress on mere beauty in type form to the production of styles of type that will meet the demand for speed in all phases of contemporary life.

This emphasis reflects something more than an adolescent mania for speed. Universal compulsory education has produced a nation of readers. Everyone now reads the daily newspaper. A large fraction of the population reads magazines as well. The increase in number of newspapers and magazines published during the past fifty years has been tremendous. Production of books has followed the same trend. Almost everyone now reads and many read voraciously. This trend has been accompanied by a similar increase in the time devoted to avocational and recreational activities. Hence, the average individual is under increased pressure to accomplish more and more within shorter and shorter periods of time. This is the meaning, in part, of the term "increased complexity of modern civilization." Thus the demand for speed merely reflects the increased tempo of modern life.

Assuming that the demand for speed will continue and may actually increase, it is apparent that improvements in typographical arrangements that will facilitate the speed with which printed materials can be assimilated will be

eagerly sought. Furthermore, traditional typographical arrangements must be subjected to tests and if found wanting, must be replaced by more efficient practices.

The increasingly important rôle of reading in all phases of modern life, together with the demand for greater speed means that even minor improvements resulting in slight gains in speed of reading will be welcomed. In all probability the race for efficiency will utilize every possible means of improving printing practices. The significance of gains in speed as small as 5 per cent will be recognized. In the total amount of reading done in the lifetime of millions of people it is clear that a saving of only 5 per cent would be of the utmost importance.

Fortunately, speed factors can be introduced into printing without sacrificing ease and comfort. Readability of print as influenced by size of type, style of type face, quality of printing surface and other factors will not only prevent or reduce fatigue and feelings of eye strain but may also facilitate the speed with which the printed material can be assimilated. Hence, speed tests as a criterion of effective typography can generally be relied upon to check the efficiency of traditional typographical practices as well as innovations.

Everyone would admit that all typography should promote rapid and easy reading. But when it comes to determining whether or not a particular typographical arrangement will be read faster than another, one's troubles immediately begin. The difficulty is due to the fact that the process of reading with understanding is a far more complicated business than is ordinarily assumed. Knowing type and type faces is one thing but to know what the "mind" of a reader will do in reading a particular piece of printed matter is quite different. Most people, printers

included, are only vaguely aware of the mental aspects of reading.

In addition to the mental aspects of reading there is an important physical side, namely, the curious and intricate eye movements that take place during reading. Everyone knows that the eyes move along the printed line and many assume that the eyes move smoothly without a break from one end of a line of print to the other. It is natural to believe that one sees clearly at all times while his eyes sweep along the line. Certainly there is nothing complicated or intricate about this sort of reading performance. But these are false notions. As a matter of fact, science has proved that the eyes, when one reads a printed line, move in a series of jumps separated by a series of pauses.[1] Furthermore, one sees clearly only during the brief pauses between jumps. For all practical purposes, one is blind during the time the eyes jump from one point on the line to another. The significant thing about these strange eye movements is the fact that the difference between a fast reader and a slow reader is found in the number of pauses, and the consistency with which the eyes move forward without retracings. The fast reader will have fewer pauses per line of print and few or no retracings. This same difference exists between good typography and poor typography. Good typography is read with fewer pauses per line and fewer instances of retracing.[2]

Unfortunately, one cannot look at a printed page and know what sort of eye movements it will bring forth. For

[1] For further information on the science of eye movements in reading see E. B. Huey, *Psychology and Pedagogy of Reading,* New York: The Macmillan Company, 1908; and M. D. Vernon, *The Experimental Study of Reading,* London: Cambridge University Press, 1931.

[2] M. A. Tinker and D. G. Paterson, "Influence of Type Form on Eye Movements." *J. of Exper. Psychol.,* 1939, 25, 528-531.

example, let the reader judge what sort of eye movements would take place when a person is instructed to look at a circle and follow carefully its outline. One would naturally believe that the eyes move smoothly with a circular motion. But the eyes actually behave in a far different manner. Figure 1 shows that the path taken by the eye in looking around the circle is very irregular.

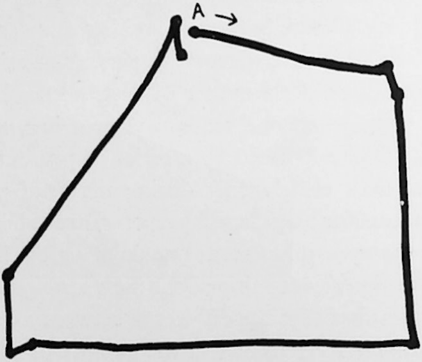

FIG. 1. Photograph of eye movements made in looking at a circle.

The same thing is true in reading a line of print. The jumps are irregular and cannot be foretold by merely looking at the words and the spacing between the words. Apparently "thought units" are far more important than word units. This is readily shown by photographic reproductions of eye movements in a variety of reading situations. Figure 2 is a picture of an eye movement camera which permits the precise reproduction of the eye movements that take place during reading. A sample record made by the camera is shown in Figure 3.

These discoveries were made in the scientific laboratory

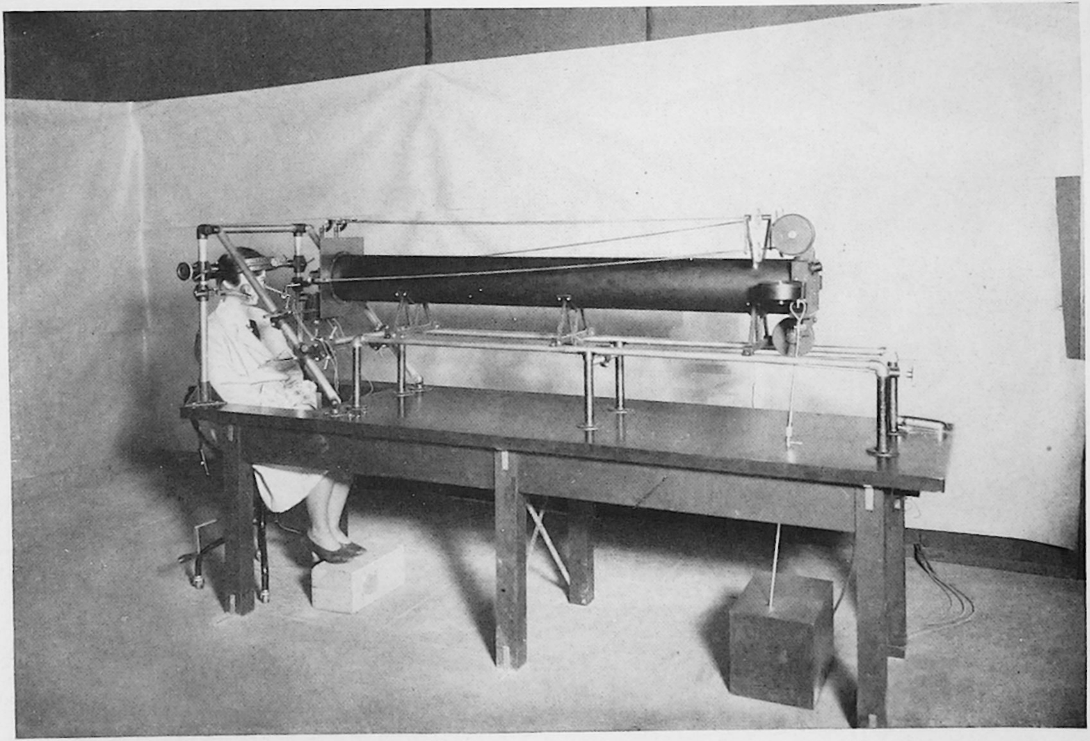

FIG. 2. Minnesota eye movement camera.

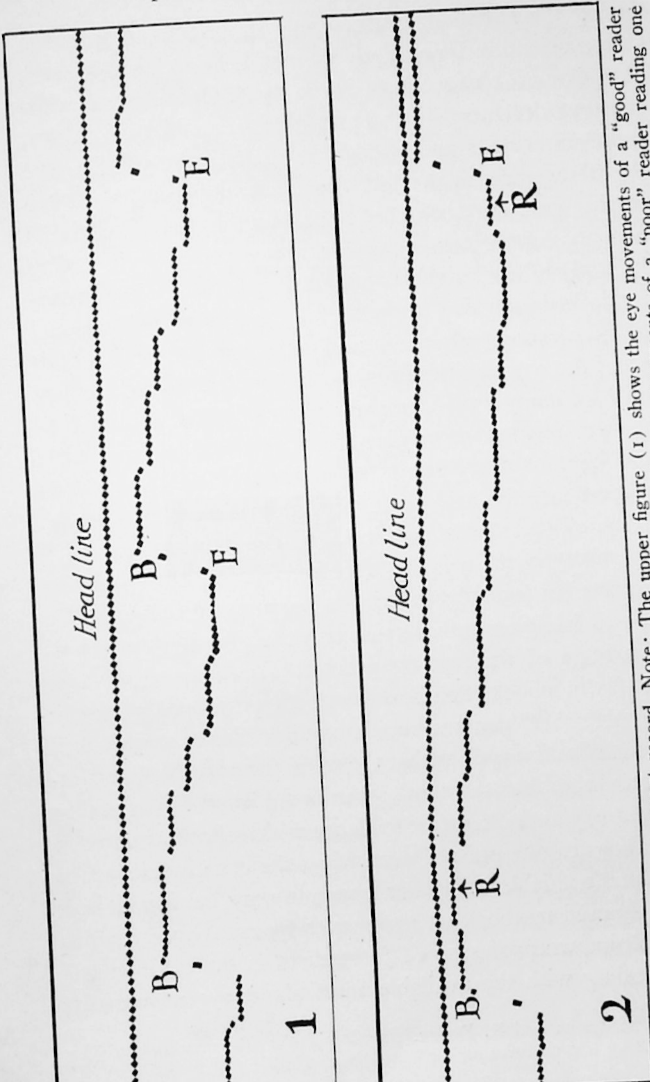

FIG. 3. A sample eye-movement record. Note: The upper figure (1) shows the eye movements of a "good" reader reading two lines of print, whereas the lower figure (2) shows the eye movements of a "poor" reader reading one line of the same text.

during the twentieth century and show beyond question that a scientific typography cannot be developed on the basis of mere observation of type itself. Opinions of printers, type designers, instructors of courses in typography, and even oculists and ophthalmologists must yield to the objective evidence derived from actual precision photographs of eye-movement behavior. But the gathering of this evidence is laborious, expensive, and necessarily limited to the study of a relatively small number of individuals reading limited samples of printing. Nevertheless, this method has been exceedingly useful in furthering our understanding of the complexities involved in simple reading and has disclosed many important principles underlying the assimilation of printed materials. Claims in behalf of particular type faces or any other typographical feature from now on must face the acid test of eye-movement photography.

One of the stumbling blocks to the development of a scientific typography is the "freedom of speech" enjoyed by "experts" in promulgating pontifical pronouncements. We refer to freely expressed opinions regarding highly technical aspects of the reading process. For example, a type founder in a booklet on how to select type solemnly assures the public that "you must see letters in order to see words." The implication is clear that the mind perceives isolated letters and combines them into meaningful words. This notion is contrary to the scientific evidence which shows that word meanings can be grasped even when the constituent letters are unidentifiable.[3] Another example may be found in a widely used textbook on newspaper typography, in which a well known professor of journalism is quite inaccurate in dealing with the available facts about eye movements

[3] B. Erdmann and R. Dodge, *Psychologische Untersuchungen über das Lesen auf experimenteller Grundlage,* Halle, 1898.

involved in reading printed material.[4] It is stated that the eye can take in a 23 to 25 pica line set in 10 point with only two "takes." He means that only two pauses of the eye would occur per line. As a matter of fact the number of pauses per line would on the average be five or six. Such misstatements would ordinarily do little damage. In the present instance, however, definite recommendations with respect to type size and line width are presented to journalism students and the recommendations are justified on the basis of an erroneous opinion concerning eye movements.

The development of a scientific typography has been exceedingly slow not only because of the difficulties involved in eye-movement photography but also because most of the non-photographic studies of typography in relation to reading performance are now known to have been inaccurate in most respects. R. L. Pyke's comprehensive survey of available studies on legibility of print completed in 1926 for the Medical Research Council in Great Britain is useful chiefly as a means of showing that the 183 research studies and reports reviewed are an unsatisfactory basis for gaining dependable knowledge.[5] Pyke appears to be on firm ground when he concludes, "the practical, typographical problems of legibility are still far from scientific solution." He goes on to point out that a scientific solution needs "fewer opinions and more facts."

Without stopping to criticize in detail the numerous studies reviewed by Pyke, it is sufficient merely to list a few of the more important errors tending to invalidate most of them. Results from studies of the legibility of type

[4] K. E. Olson, *Typography and Mechanics of the Newspaper*, New York: D. Appleton and Company, 1930, p. 204-206.

[5] R. L. Pyke, *Report on the Legibility of Print*, London: H. M. Stationery, 1926.

faces, obtained by exposing isolated letters or groups of letters at a distance and noting the errors in reading them, cannot be accepted as universally valid. Reading prose is a function of grasping "thought units" and not a function of adding together single letters. Also reading letters at a distance does not duplicate ordinary reading conditions. What may be true for "distance reading" is not necessarily true for "ordinary reading." The same criticism may be levelled at those who have employed brief exposure methods such as the tachistoscope in measuring legibility.

Comparisons between the ordinary reading of material set up in one arrangement and other arrangements would appear to be a sounder method of approach. This method yields a direct measure of the effect of any particular typographical arrangement on speed of reading. Large numbers of subjects may be tested and, if group methods of testing are employed, data from many individuals may be secured within relatively short periods of time.

It should be noted, however, that there is no conflict between the reading performance method and the photographic technique. Whatever results are obtained by one method should be in agreement with the results from the other. The reading performance method enables one economically to determine the relative efficiency of different typographical arrangements. But such mass results do not reveal just *why* one typographical arrangement is better than another. This would be disclosed only by the photographic method. Thus the latter method permits analysis of the significant findings yielded by reading performance tests.

Simple as this reading performance method appears to be, there are, nevertheless, numerous pitfalls not readily apparent. We refer to the failure of investigators to use

reading materials of equal difficulty when comparing different typographical set-ups, or to a failure to use enough reading material and enough readers to establish beyond question the accuracy of the findings. Reliance on a brief paragraph or two and on a dozen or less readers will not do. Another important shortcoming is an almost universal failure to supply any check on the actual comprehension achieved in any experimental session. For example, it has been customary to measure the time required to read a passage without checking the degree of understanding. A further common defect is a failure to duplicate actual printing practice in the experiments. For instance, several investigators have compared the legibility of differences in type sizes by photographically reducing and enlarging a given printed piece of copy. These investigators forget that photographic reductions and enlargements destroy the letter proportions which would exist if larger and smaller type sizes were used. A final criticism is statistical in nature,—failure to use approved mathematical methods of analyzing results obtained in various experiments. For these reasons, it is safe to conclude that, up to the present time, little dependable knowledge has been derived from non-photographic studies of typography.

The results reported in the following chapters are based on direct comparisons of speed of reading records obtained from individuals subjected to different kinds of printing. In all these comparisons care was taken to avoid the pitfalls enumerated above. Eighty or more individuals were tested for each and every comparison made. Appropriate statistical methods were employed in the mathematical analysis of results. The modern method of group testing was utilized so that each individual read sufficient printed material to permit a definite conclusion regarding the effectiveness

of a particular typographical arrangement. The reader interested in the technical aspects of the methods of investigation used, should consult the detailed account of our methodology as given in Appendix I.

It should be pointed out that care was taken to print all test forms according to standard printing practices so that our results may be applied directly to printing in general. Furthermore, the speed of reading tests were read under natural reading conditions, each reader adjusting the distance between eyes and paper to suit his normal reading habits. Normal reading conditions were also preserved by testing college students and school children in their regular classrooms. As is well known, students are accustomed to all sorts of tests. So when we presented our speed tests they responded naturally and gave every indication of hearty cooperation. In addition, we deliberately refused to exercise any control over illumination. Some tests were given on bright sunny days. Other tests were administered on cloudy days under artificial illumination which was sometimes good and sometimes poor. Far from being a defect, these differences in illumination constitute a virtue in our experiments. Such variations permitted us to test out different typographical arrangements under the varieties of lighting that characterize reading in everyday life. Had we rigidly controlled illumination under artificial laboratory conditions we could not be so certain that our findings would hold for ordinary life situations. Finally, no attention was paid to the possible existence of eye defects among any of the readers. We were not interested in measuring the effectiveness of various typographical arrangements when reading is done by persons with "perfect" eyes. One typographical arrangement must compete with another not under ideal conditions of perfect eyesight,

but under the practical conditions of everyday life where eyesight varies from good to poor.

Another obstacle to the development of an adequate science of typography is to be found in the large number of factors involved in the organization of a printed page. What style of type face to use is a perennial question. Some argue that type faces in common use differ greatly in legibility. Others disagree. Similar differences of opinion exist with reference to the most legible size of type. And so it goes with respect to width of line, leading or space between lines, printing surfaces, margins and intercolumnar spacing. Thus the whole subject is not only in a state of great confusion, but the actual number of typographical factors is so great as to defy simple exposition.

As we investigated the legibility of each of the above factors, one at a time, the complexity of our problem increased. We found, for example, that combinations of two or more of these factors may produce different results than would be expected from knowledge of each of the factors taken separately. Thus it became necessary to study combinations.

Needless to say, we do not claim that the results reported in subsequent chapters constitute a *completed* science of typography. We have recognized the complexity of the problems, however, and have isolated and studied the more important factors and the more important combinations in an attempt to lay a foundation. In doing so, we have given 66,062 reading tests to 33,031 persons.

It is one thing to lay the foundation for a scientific typography and another to get the findings accepted by the printing industry. It is obvious that tradition and custom play a big rôle in current printing practice. Furthermore, most printers hold decided opinions in regard to what is

most legible even though they do not agree one with another. This state of affairs makes it exceedingly difficult for scientific facts to get a fair hearing. We are convinced, however, that if and when the scientific findings are incorporated into current printing practice there will be an appreciable advance in the development of a high speed typography.

Chapter 2

Kinds of Type

1. Styles of Type Face

Books on typography devote far more space to descriptions of type faces and their uses than to all other typographical factors combined. Judged merely by space allotments one might conclude that printers, advertisers and publishers believe that the topic of styles of type is far more important than such factors as size of type, line width, and leading.

In all of these discussions the emphasis is upon appropriateness of particular type faces for conveying particular kinds of messages. Questions of legibility are rarely treated and when treated the findings of Roethlein tend to be relied upon.[1] Unfortunately, the facts derived from Roethlein's investigation have little or no bearing on the question at issue since she merely investigated the relative legibility of isolated letters at a distance. As pointed out in the preceding chapter, reading is not a process of perceiving letters in isolation at a distance. Thus, we urgently need facts based upon tests of reading speed obtained under natural reading conditions in order to permit valid conclusions regarding the relative legibility of various styles of type faces.

In selecting styles of type for our experiments we con-

[1] B. E. Roethlein, "The Relative Legibility of Different Faces of Printing Types." *Amer. J. Psychol.*, 1912, 23, 1-36.

Scotch Roman

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as

Garamond

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as I

Antique

3. This morning my mother asked me to find out what time it was. I therefore ran just as

Bodoni

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as

Old Style

3. This morning my mother asked me to find out what time it was. I therefore ran just as

Caslon

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as

Kabel Light

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as I could to

Cheltenham

3. This morning my mother asked me to find out what time it was. I therefore ran just as rap-

American Typewriter

3. This morning my mother asked me to find out what time it was. I therefore

Cloister Black

3. This morning my mother asked me to find out what time it was. I therefore ran just as rapidly as

Fig. 4. Styles of type face.

sulted a total of thirty-seven publishers and printers. Replies indicated a lively interest in our proposed investigation and contained numerous suggestions as to which type faces should be compared. Since it was impossible to include all suggestions or to include all possible type faces, we selected the following seven frequently recommended type faces: Scotch Roman, Garamond, Antique, Bodoni, Old Style, Caslon Old Style, and Cheltenham. In addition, we included three type faces which depart radically from the foregoing, namely, Kabel Light, American Typewriter, and Cloister Black (Old English). Figure 4 reproduces a sample of each of these type faces as set up and used in our experiment.

It was assumed that a fairer comparison of these ten type faces would be obtained if enamel paper stock were used throughout. Uniformity in paper stock was essential and we believed that enamel paper stock would bring out the best qualities of all type faces used. Type suitable for soft paper presumably will be satisfactory with enamel paper stock, whereas type suitable for hard paper might not yield satisfactory results on soft paper.

Each type face was compared with Scotch Roman as a standard. Thus Form A of the Chapman-Cook Speed of Reading Test was set up in Scotch Roman, 10 point, 19 pica line width, set solid for each of the ten comparisons. Form B of the same test was printed in exactly the same manner except for variations in type faces as shown in Figure 4. Ninety college students read Forms A and B in each comparison, making a total of 900 subjects participating in the whole study. The results are shown in Table 1.

Inspection of these results shows that type faces in common use do not differ greatly with respect to the speed with

TABLE 1*

Speed of Reading Various Styles of Type Face in Comparison with Scotch Roman as a Standard

Note: Plus (+) differences indicate faster and minus (–) differences indicate slower reading than the standard. Number of readers = 90 in each test group or 900 in all.

Type Face	Differences in Per Cent
Scotch Roman	0.0
Garamond	+0.4
Antique	–0.2
Bodoni	–1.0
Old Style	–1.1
Caslon, Old Style	–1.3
Kabel Light	–2.2
Cheltenham	–2.4
American Typewriter	–4.7
Cloister Black	–13.6

* For this and all other studies reported in the main portion of this book, tables of detailed results as listed in Appendix II may be obtained from the American Documentation Institute.

which they are read. American Typewriter and Cloister Black (Old English), however, are read more slowly than the type faces in common use. The former exerts approximately a 5 per cent retarding influence and the latter slows up reading about 14 per cent.

Apparently type faces in common use are equally legible under conditions of ordinary reading. At first thought, this result may appear to be quite surprising. One must remember, however, that such type faces as Scotch Roman, Bodoni, Caslon, etc., have survived in competition with hundreds or even thousands of type faces designed and put on the market. Thus, these results suggest the evolu-

tionary principle of "survival of the fittest." Those type faces which survive the relentless competitive struggle for existence are shown by our experiment to be equally fit.

It is significant that an ultra modern type face such as Kabel Light is practically as legible as type faces in common use. It is possible that Kabel Light might prove to be slightly more legible than the other type faces used in this study were our readers accustomed to it. At the present time, however, the evidence suggests that there is a slight disadvantage in its use as far as speed of reading is concerned.

The retarding effect of American Typewriter type is probably due to the impossibility of adjusting the spacing between letters of typewriter type. Thus, characteristic word forms are distorted. It is also possible that details of letter form are partly responsible for the slower reading produced by typewriter type.

The decided illegibility of Cloister Black is probably due to the fact that such type involves "too many nooks and corners, too many angles and curly-cues."[2]

Our results are not in agreement with the findings reported by Roethlein,[3] and by Burtt and Basch.[4] As pointed out before, Roethlein's experiment (and the Burtt and Basch experiment as well) deals with the perceptibility of isolated letters and meaningless groups of letters, and therefore fails to duplicate ordinary reading conditions. In contrast, our method directly attacks the comparative legibility of type faces in an actual reading situation. For this

[2] D. Starch, *Principles of Advertising,* New York: A. W. Shaw Company, 1923.

[3] *Op. cit.*

[4] H. E. Burtt and C. Basch, "Legibility of Bodoni, Baskerville Roman, and Cheltenham Type Faces." *J. Appl. Psychol.*, 1923, 7, 237-245.

reason, we believe that our results have more significance for the printing industry.

While our results do not agree with the Roethlein experiment, it is noteworthy that they do agree with the viewpoint expressed in the Pyke report.[5] He put forth the belief that differences in type faces would have to be very radical indeed in order to bring about appreciable differences in legibility in everyday reading situations. Our findings derived from 900 readers in an actual reading situation support Pyke's contention.

In summary, our data clearly indicate that type faces in common use are equally legible. In other words, the evidence derived from our reading performance test technique confirms printing customs and practice in preferring any one of several "standard" Roman type faces.

Statements regarding the comparative legibility of different type faces are likely to reflect mere opinion. To determine the trustworthiness of such statements we conducted a special study of opinions regarding the relative legibility of the ten type faces used in our reading performance tests. Printed samples of the ten type faces were presented to 210 college students who were instructed "to arrange them in order from most legible (rank 1) to least legible (rank 10)." The students were directed to "consider that these samples are taken from books or magazines and that legibility means 'ease and speed of reading.'" The average rank assigned to each sample of printing was computed. The results appear in Table 2.

According to the combined judgment of these 210 students, important differences in legibility exist between these type faces. Roughly, the students sub-divide the type faces into six distinct steps of legibility. Cheltenham and

[5] *Op. cit.*

TABLE 2

Styles of Type Face Ranked According to 210 Reader Opinions of Relative Legibility

Type Face	Average Rank	Rank Order
Cheltenham	2.3	1
Antique	2.4	2
Bodoni	4.2	3
Old Style	4.6	4
Garamond	5.4	5
American Typewriter	5.5	6
Scotch Roman	6.2	7
Caslon, Old Style	6.4	8
Kabel Light	8.2	9
Cloister Black	9.8	10

Antique are grouped together as distinctly more legible than the remainder. Next come Bodoni and Old Style. Then Garamond and American Typewriter are ranked as of medium legibility. Scotch Roman and Caslon Old Style are grouped at the fourth step in decreasing legibility. Kabel Light is put in a class by itself and Cloister Black is considered least legible of all.

The only point of real agreement between these rankings and the objectively determined results is in regard to the poor legibility of Cloister Black. The failure of the students to recognize that American Typewriter is less legible than standard type faces in common use may be accepted as impressive evidence of the difficulty and probably the impossibility of deciding questions of legibility by mere inspection of printed material. The fact that six distinct steps in legibility are recognized in the rankings whereas in reality only three exist for these ten type faces also discredits attempts to determine legibility by mere inspection.

The results of this special study should be accepted as

evidence that mere opinions concerning matters of typography are unsafe guides.

There is a practical value to "opinions," however, that should not be overlooked by the printer who desires to cater to the preferences of his readers. Since legibility differences are slight or practically non-existent, the printer can follow "reader preference" without decreasing legibility. In so doing, his printed copy, if set in Cheltenham or Antique, will give the impression of being easily and speedily read. These two faces differ from the others mainly *in approaching the appearance* of bold face type. From the point of view of the psychology of the reader, therefore, Table 2 is of greater value to the printing industry than is Table 1. We have tried to capitalize on these facts by specifying that this book be printed in Cheltenham or in a type face closely approximating either Cheltenham or Antique. A word to the wise is sufficient.

2. Italics versus Lower Case

The opinion is widely held among printing experts that italic type is far less legible than lower case. In part, this view is undoubtedly due to a certain feeling of strain when one merely looks at a page of italics to say nothing of the discomfort experienced when one attempts to read it. In addition, Starch as early as 1914 described an experiment in which he compared the time required to read text set in italics and to read similar material set in lower case. He stated, "The test showed that the italic text was not read as rapidly as the Roman text."[6]

[6] Daniel Starch, *Advertising,* New York: Scott, Foresman & Company, 1914, pp. 181-182; also Daniel Starch, *Principles of Advertising,* New York: A. W. Shaw Company, 1923, pp. 657-658.

Since Starch is the only person who appears to have investigated the readability of italic text and since he failed to report specific results, we undertook to ascertain the degree to which italic text retards speed of reading. A total of 320 persons was required to read one text set up in lower case, Old Style, 10 point, 19 pica line width, set solid, on eggshell paper stock and to read another text set up in Old Style italics, all other printing specifications being the same. The results, as shown in Table 3, indicate that italic type retards reading 2.7 per cent.

TABLE 3

Speed of Reading Old Style Lower Case and Old Style Italics

Number of Readers = 320

Type Form	Average Amount Read	Differences in Per Cent
Lower Case	18.26	−2.7
Italics	17.77	

The small retarding effect of italics is somewhat surprising. Here again there is a discrepancy between objectively measured results and the opinions of experts. We would emphasize the importance of accepting the measured results. Moreover, these results are understandable when we note the typographical similarities between lower case printing and italics. In the first place, the printed material in italics covers exactly the same amount of printing surface as does lower case. Presumably the number of visual fixations per line of print would, therefore, be the same for both kinds of text. In the second place, word form in italic printing is almost identical with word form

in lower case. This means that perceptual cues essential for rapid reading would be approximately the same.

Our sampling of reader opinions regarding the relative legibility of lower case versus italics reveals that the typical reader agrees with printing experts in believing that printing in italics retards speed of reading. When we asked 224 college students to rank samples of printing in lower case and in italics according to apparent legibility we found that 94 per cent agreed that lower case would be read more rapidly than italics. See Table 4.

TABLE 4

Lower Case versus Italics Ranked According to 224 Reader Opinions of Relative Legibility

Type Form	Average Rank	Percentage of Votes for First Place
Lower Case	1.1	94
Italics	1.9	6

In spite of the small differences found, we would not minimize the possibility that italics may involve greater discomfort and greater expenditure of energy. As far as speed goes, however, italics is only slightly less efficient than lower case. The fact that it is slightly less efficient, and appears to involve greater strain suggests the wisdom of using italics sparingly. *The use of italics should be restricted to those rare occasions when added emphasis is desired.*

3. All Capitals versus Lower Case

The decreasing use of "all capitals" in newspaper headlines and in advertising copy suggests that printers and

advertising experts are coming to believe that lower case text is more legible.[7] Evidence, however, is strangely missing with the exception of one minor study conducted by Starch in 1914.[8] He reported that text set in lower case is read 10 per cent faster than similar material set in all capitals.

The results of our study of all capitals versus lower case are presented in Table 5. A total of 320 readers was used (none of these readers performed in the italics study

TABLE 5

Speed of Reading Old Style Lower Case and Old Style All Capitals

Number of Readers = 320

Type Form	Average Amount Read	Differences in Per Cent
Lower Case	18.83	−11.8
All Capitals	16.61	

or in any of our other studies). The printing specifications were the same for this experiment as for the preceding experiment, all capitals being substituted in one piece of text for the italics. It is apparent that all-capitals text retards speed of reading to a striking degree. The difference is almost 12 per cent. Few typographical factors can be found which will retard reading to this extent.

At least three reasons can be found which will account for the poor legibility of all capitals.

[7] H. D. Kitson, *Scientific Advertising*, New York: Codex Company, 1926, pp. 8-11.

[8] D. Starch, *Advertising*.

(1) The printing surface required for the all-capitals text was 35 per cent greater than for the same material set in lower case. Thus, the number of visual fixations would be greatly increased for the all-capitals text.
(2) The word form is far more characteristic when words are printed in lower case than when they are printed

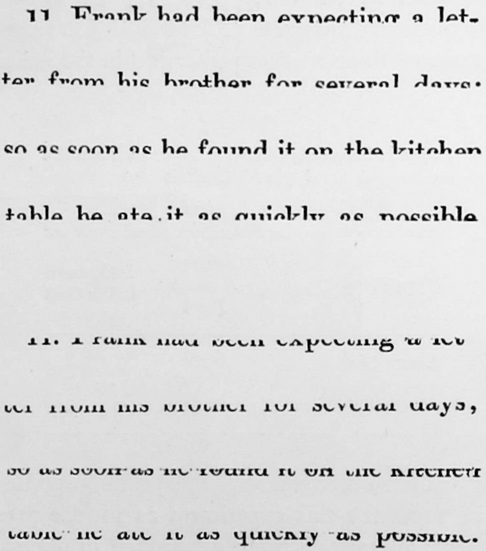

Fig. 5. Showing that the upper half of a printed line furnishes more cues to "word form" than the lower half.

in all capitals. See Figures 5 and 6 for illustration of the importance of "word form" clues.
(3) Reading habits favor lower case since practically all of our reading is concerned with lower case printing rather than all capitals.

The opinions of 224 readers were also secured in re-

gard to the relative legibility of all-capitals and lower case text. The results, shown in Table 6, indicate again that the

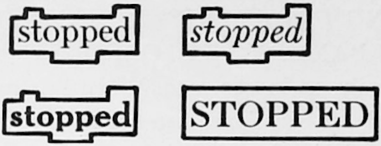

FIG. 6. Block outlines of the printed word "stopped" to illustrate that lower case, italics and bold face exhibit a characteristic "word form" whereas "word form" is absent when printed in all capitals.

consensus is in favor of lower case printing as being more legible than all capitals.

TABLE 6

Lower Case versus All Capitals Ranked According to 224 Reader Opinions of Relative Legibility

Type Form	Average Rank	Percentage of Votes for First Place
Lower Case	1.1	90
All Capitals	1.9	10

In view of the magnitude of the difference in legibility between lower case and all capitals, as measured by reading tests and by reader opinion, we would strongly recommend that all-capitals printing be eliminated where speed of perception is at a premium. Strangely enough, printing in all capitals survives just in those situations where speed of perception is especially important. We refer to posters, car cards, billboards, newspaper headlines, newspaper and magazine advertising copy (headlines and text), headings

in business forms and records, labels on packages, titles on book jackets, and a "thousand and one" other types of printing. THE HEADLINE WRITER AND THE ADVERTISING COPY WRITER SHOULD HENCEFORTH ABANDON ALL CAPITALS **and should rely primarily on lower case**. When this rule is generally adopted, an occasional use of all capitals might be justified as a device for attracting attention.

4. Bold Face versus Ordinary Lower Case

Printing in bold face type is frequently resorted to as a means of emphasis. Knowledge of the extent to which such a practice affects legibility is lacking except for Roethlein's experiment and a special study conducted by W. D. Scott on railroad time-tables. In the Roethlein experiment it is clear that bold face letters can be perceived at a greater distance than ordinary lower case letters. In the Scott study six subjects merely read as fast as possible two pages of railroad time-table set in light-faced small type and in heavy-faced large type on the same body. Thus three uncontrolled factors (size, leading, and heaviness of type face) were involved in the study. Therefore, the advantage found for the heavy-faced type may have been due to the size of the type rather than to the heaviness of the face. At all events neither study gives results which are applicable to ordinary printing practice.

Our study shows that neither bold face nor ordinary lower case printing has an advantage over the other in legibility. See Table 7.

Reader opinion, however, favors ordinary lower case printing in a ratio of about two to one. This is shown in Table 8.

TABLE 7

Ordinary Lower Case versus Bold Face

Reading speed for bold face printing is compared with reading speed for ordinary lower case as the standard. Minus (–) differences indicate slower reading than the standard. Number of readers equals 100 college students in each test group or a total of 200 in all.

Type Form	Differences in Per Cent
Lower case vs. Lower case	0.0
Lower case vs. Bold face	–0.1

TABLE 8

Ordinary Lower Case versus Bold Face Ranked According to 224 Reader Opinions of Relative Legibility

Type Form	Average Rank	Percentage of Votes for First Place
Ordinary Lower Case	1.3	70
Bold Face	1.7	30

5. Summary and Recommendations

1. In spite of the opinions of publishers and printers as well as of readers to the effect that marked differences in legibility will characterize different type faces, our tests show that type faces in common use are equally legible. Printers who desire to cater to reader preferences will adopt a type face that appears to border on bold face such as Antique and Cheltenham.

2. American Typewriter type retards reading by about 5 per cent and should not be used in printing practice unless a novelty effect is desired.

3. Old English type retards reading to such a marked degree that its use should be restricted to those printing situations where brief messages of a sacred, solemn or formal kind are involved.

4. Ultra modern type such as Kabel Light retards reading only to a slight degree and hence may be freely used in advertising copy and possibly even in book and magazine printing.

5. Material printed in italics is read almost as fast as material printed in ordinary lower case. It is possible, however, that the reading of italics involves eye strain. Readers believe that lower case printing can be read faster than italics. The use of italics, therefore, should be restricted to those rare occasions when added emphasis is desired.

6. Material set in all capitals is read 12 per cent more slowly than material set in lower case. Reader preferences are overwhelmingly in favor of lower case. Printers, advertising copy writers and newspaper publishers would be wise to eliminate printing in all capitals, not only from text material but also from headlines as well.

7. Although bold face printing is read as rapidly as ordinary lower case, nevertheless, its use should be restricted to occasions when emphasis is desired since reader preferences are definitely against it. Bold face printing, however, should be freely used for car cards, posters, etc., since the evidence shows that it is far more legible when read at a distance.

Chapter 3

Size of Type

1. Opinions and Evidence

TYPE size is regarded by many as being fully as important as the question of type face. This attitude is reflected in letters received from printers and publishers who were kind enough to advise us in regard to the styles of type faces we should include in our studies. The following quotations taken from these letters, are illustrative:

(1) "We note your experiment is to be limited to ten-point type which seems to us a mistake because it is quite unusual for school books to be set in any type smaller than eleven point."

(2) "Our rule is to use 11-point rather than 10-point. . . . 10-point is now regarded as too small for use in regular straight text."

(3) "I think I should point out to you that 10-point is rather small for book work."

(4) "Children's books, fiction and general books of wide appeal, cannot well be printed in anything smaller than 11 point."

On the other hand, such a careful student of typography as Walter states, "Ten point is very commonly used for books, bulletins, reports, and other publications intended for easy or consecutive reading."[1]

[1] F. K. Walter, *The Library's Own Printing,* published by American Library Association, Chicago, 1934, p. 24.

Pyke's historical review[2] of the studies concerning type size and legibility shows a similar lack of agreement among investigators. Griffing and Franz, Javal, and Roethlein held that size of type is the most important factor in legibility. Huey, after summarizing the available evidence, concluded: "The size of type is perhaps the most important factor in legibility." On the other hand, Babbage, Freeman, Judd, and the 1922 Committee on Type Faces and Government Printing either deny the significance of type size as a factor in legibility or minimize its importance by emphasizing the greater importance of interlinear spacing.

Authorities in the field of the psychology of advertising would probably agree as to the importance of size of type in relation to speed of reading. Presumably because of the absence of experimental evidence, these authors either fail to mention the problem or discuss it in rather general terms.[3] Starch comments on the large number of advertisements containing type as small as 5 and 6 point to be found in the 1880's. He reports that 85 per cent of the full-page advertisements in the *Century Magazine* in 1881 had the main body text printed in 8 point type or smaller. The percentage, however, became less with each succeeding decade. Thirty years later (1910) only 5 per cent were found to use such small type. These figures may be accepted as evidence that advertising experts in their efforts to improve the readability of their copy have abandoned the smaller sizes of type.

[2] R. L. Pyke, *The Legibility of Print*, Medical Research Council, Special Report No. 110, His Majesty's Stationery Office, London, 1926, pp. 21-22. See Pyke's bibliography for references.

[3] See D. G. Paterson and M. A. Tinker, "Size of Type." *J. Appl. Psychol.*, 1929, 13, 120-130.

Only four serious investigations of type size and legibility have been reported in the scientific literature, namely the studies by Blackhurst, Gilliland, Griffing and Franz, and Roethlein. (See Footnote 3.) Unfortunately the Roethlein study does not give information that is applicable to ordinary reading situations. The other three studies are so seriously defective from a methodological point of view that they do not contribute significant or useful knowledge.

2. Printing Practice

In view of the lack of agreement regarding optimal type size among experts and investigators it would be natural to find considerable diversity of practice among printers in type size usage. We have, therefore, surveyed printing practice to get a picture of current usage. Our survey included American and foreign scientific journals, textbooks in five fields of knowledge, and American non-scientific magazines. A total of 1500 books and magazines was

TABLE 9

Survey of Printing Practice with Reference to Size of Type

Note: Results are given in terms of percentage distributions.

	Type Size in Points						
	7	8	9	10	11	12	14
100 American Non-Scientific Journals	1.0	7.0	32.0	45.0	7.0	0.0	0.0
200 American Scientific Journals	0.0	2 5	5.0	68.5	19.0	5.0	0.0
200 Foreign Scientific Journals	0.0	0.5	11.0	34.5	48.0	6.0	0.0
200 History Texts	0.0	0.0	0.0	18.0	33.5	47.5	1.0
200 Education Texts	0.0	0.5	2.0	35.5	44.0	18.0	0.0
200 Psychology Texts	0.0	0.0	1.0	33.5	34.0	31.0	0.5
200 Economics Texts	0.0	0.0	1.5	32.0	42.0	24.5	0.0
200 Literature Texts	0.0	1.0	6.0	22.0	40.5	27.5	3.0

studied. The results are presented in Table 9. Textbook printing is confined to 10, 11, and 12 point type with approximately one-third of the books being printed in each of these sizes. Over two-thirds of the American scientific journals are printed in 10 point, one-fifth in 11 point, and a small percentage in 8, 9, or 12 point. The foreign scientific journals used the same type sizes but with a definite tendency to prefer 11 point. American non-scientific magazines show a heavy concentration at 9 and 10 point sizes.

Several questions immediately arise in one's mind as he scrutinizes Table 9 and realizes the diversity of practice. Is this diversity justified? If so, then legibility differences between 9, 10, 11, and 12 point type sizes must be negligible. Do scientists and students require larger sizes of type than the average reader of general magazines? If differences in legibility between the type sizes here considered are really negligible, what justification is there for the use of 11 and 12 point type? Unit costs of production would dictate the use of smaller type sizes. A mere listing of these questions shows how important it would be to have definite knowledge as to the legibility of type sizes.

3. Two Studies of Type Size

It is clear that definite information regarding the actual relationship between type size and speed of reading is urgently needed. In the present chapter we report two studies of type size keeping width of line constant at 19 picas, all material set solid and printed on eggshell paper stock.

In the first study Scotch Roman type face was used and the test materials were printed in 6, 8, 10, 12, and 14

point type. Variations in type size are shown in Figure 7. The results are presented in Table 10. It would seem that

6 point

16. This band of men and women set sail for the new world where they could live in peace. There was great rejoicing when

8 point

16. This band of men and women set sail for the new world where they could live in peace. There was great rejoicing when

9 point

16. This band of men and women set sail for the new world where they could live in peace. There was great rejoicing when

10 point

16. This band of men and women set sail for the new world where they could live in peace. There was

11 point

16. This band of men and women set sail for the new world where they could live in peace. There was

12 point

16. This band of men and women set sail for the new world where they could live in peace.

14 point

16. This band of men and women set sail for the new world where they

FIG. 7. Seven sizes of type set solid, 19 pica line width. Six through 12 point are Granjon, 14 point is Scotch Roman.

type sizes smaller than 10 point, and 12 point or larger tend to retard speed of reading from 4.9 to 6.4 per cent.

This study of size of type as reported in Table 10 was one of the earliest in our series of investigations. At that time we did not include a "control group," so we cannot

TABLE 10

Size of Type: Study 1

Reading speed for 6, 8, 12, and 14 point type is compared with reading speed for 10 point type as the standard. All tests were printed in 19 pica line widths, set solid. Minus (−) differences indicate slower reading than the standard. Number of readers = 320 college students.

Size of Type	Differences in Per Cent
10 point vs. 6 point	−5.8
10 point vs. 8 point	−4.9
10 point vs. 12 point	−5.5
10 point vs. 14 point	−6.4

be sure that the retardation shown is entirely due to changes in type size alone. It is possible that a constant error in the test situation may have produced a part of these losses in speed. This study also utilized the 30 paragraph arrangement, a fact which, so far as we can see, would not affect the results. Furthermore, the study was incomplete since it neglected the smaller variations in type size which are actually found in printing practice. We refer to the fact that the study did not include 9 point and 11 point type.

To remedy the possible shortcomings of this first study of type size, we repeated the experiment at a later date with a control group and the use of the 6 unit printing arrangement. Variations in type size were as follows: 8, 9, 10, 11, and 12 point. In order to secure printed copies of our test materials in these particular type sizes it was necessary to use Granjon type in place of Scotch Roman. The results are shown in Table 11.

It is clear from this table that 8 point and 12 point are

TABLE 11

Size of Type: Study II

Note: Reading speed for 8, 9, 11, and 12 point type is compared with reading speed for 10 point as the standard. Granjon type face was used with a 19 pica line width, set solid. Minus (–) differences indicate slower reading than the standard. Number of readers equals 95 college students in each test group or a total of 475 in all.

Size of Type	Differences in Per Cent
10 point vs. 8 point	−3.8
10 point vs. 9 point	+2.3
10 point vs. 10 point	0.0
10 point vs. 11 point	+5.1
10 point vs. 12 point	−2.1

read slightly more slowly than 10 point although the loss in reading speed for these two type sizes is not as great as was apparently found in our first study. The fact that the two studies do not agree concerning the magnitude of the retarding effects would lead us to minimize the significance of the findings in our first study on type size. The further fact that the control group in the second study on type size shows no difference in speed of reading Forms A and B would lead us to accept the findings in Table 11 rather than those in Table 10. If this is done then we are forced to conclude that 9 point type is read as fast if not slightly faster than 10 point, and 11 point type is actually read significantly faster than 10 point. Here is experimental justification for a tendency to print books and foreign scientific magazines in 11 point type. On the whole one is forced to conclude that type size is not as important a factor in legibility as previous writers have claimed. Apparently one can vary type size from 8 point to 12 point without mark-

edly affecting the speed with which printed material can be read.

The opinions of 224 readers were secured in regard to the relative legibility of the type sizes employed in Study II. The results, shown in Table 12, indicate a consensus definitely in favor of 11 point type. Reader opinion selects 10 point and 12 point type as a close second to 11 point.

TABLE 12

Sizes of Type Ranked According to 224 Reader Opinions of Relative Legibility

Size of Type	Average Rank	Rank Order
8 point	4.7	5
9 point	3.7	4
10 point	2.4	2.5
11 point	1.9	1
12 point	2.4	2.5

There is a definite tendency to relegate 9 point and 8 point types to fourth and fifth places respectively. These results would justify the use of 11 point type, not only from the viewpoint of objective results but also from the viewpoint of reader opinion.

4. Interpretation of Results on Type Size

It is difficult to resist the tendency to draw a final conclusion in regard to type size on the basis of the data presented in Tables 10 and 11. One must remember, however, that in addition to type size the factors of line width and interlinear spacing are necessarily involved and should be taken into consideration in any final judgment about type size. All three factors should be studied under conditions where systematic variation of all three is made. Only

under these conditions will final results be significant. For this reason the reader should suspend judgment in regard to type size pending our detailed presentation of the effects of all three factors varied simultaneously. These results will be presented in Chapter VII together with specific recommendations.

Chapter 4

Width of Line

1. Introduction

A LIVELY interest in the effect of line width[1] upon speed has been exhibited by psychologists, educators, advertisers, publishers, and others. Unfortunately, this interest has led to definite recommendations rather than to careful experiments and investigations. The recommendations themselves are contradictory. Some writers urge long lines; whereas others advocate short lines. Figure 8 illustrates variations in line width for 8 point type. Weber[2] recommends line widths from 24 to 36 picas, whereas Kleppner's[3] recommendations emphasize the desirability of excessively short lines, namely, 13 to 16 picas for 10 point type and 9 to 13 picas for 8 point type. Dearborn[4] advocated line widths from 18 to 20 picas and most investigators place the optimal line width at about 22 picas. The trend of opinion on the whole favors relatively short lines.

A detailed review of the literature is superfluous be-

[1] In the literature most writers refer to this typographical feature as line length. Since the technical term in the printing industry is "width of line" we have come to use the term *width* instead of *length.*

[2] A. Weber, *Ueber die Augenuntersuchungen in den höheren Schulen zu Darmstadt.* Referat und Memorial erstattet der grosshersoge Ministerial. Abtheilung für Gesundheitspflege. Marz, 1881.

[3] O. Kleppner, *Advertising Procedure,* New York: Prentice-Hall, 1927, pp. 228 and 523.

[4] W. F. Dearborn, *The Psychology of Reading,* Columbia University Contribution to Philosophy and Psychology, xiv, No. 1, 1906.

and left without his change. When the boy ran and

21 picas

6. Mr. Smith gave a newsboy a quarter for a paper and left
without his change. When the boy ran and told him he said he

25 picas

6. Mr. Smith gave a newsboy a quarter for a paper and left without
his change. When the boy ran and told him he said he had never

29 picas

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When

cause of the absence of adequate experimentation. Verification of this statement can be found by scrutinizing the literature reviewed by Pyke.[5] In spite of the fact that writers tend increasingly to recommend short lines, we are convinced on the basis of our studies that optimal line widths may be much longer than have usually been suggested. In fact our own views have undergone a radical revision since we published our first study on the subject.[6] At that time our views were in harmony with the trend of recommendations in the literature. Further experimentation, however, forced us to abandon our previous position. We are now inclined to believe that line width is less important than interlinear spacing and size of type.

2. Printing Practice

Our survey of printing practice yielded the results shown in Table 13. Because it has long been the practice to print American non-scientific journals with two or more columns per page and because of the recent tendency to print American scientific journals with two columns to the page it was necessary to break Table 13 into two parts showing results for multiple-column printing and for single-column printing. It is obvious that there is no single preferred line width in double-column printing. American non-scientific journals show variations in line widths from 12 to 22 picas, whereas American scientific journals vary the line widths for the most part between 13 and 18 picas.

Single-column printing in American and foreign journals tends towards relatively long line widths, i.e., 23 to 28

[5] R. L. Pyke, *The Legibility of Print*.
[6] M. A. Tinker and D. G. Paterson, "Length of Line." *J. Appl. Psychol.*, 1929, 13, 205-219.

TABLE 13

Survey of Printing Practice with Reference to Width of Line

Note: Results are given in terms of percentage distributions.

	Line Width in Picas—Double-Column Printing						
	11–12	13–14	15–16	17–18	19–20	21–22	23–24
93 American Non-Scientific Journals	2.2	32.2	12.9	12.9	20.4	17.2	2.2
54 American Scientific Journals	5.6	27.8	21.2	35.2	9.2	0.0	0.0

	Line Width in Picas—Single-Column Printing								
	Less Than 17	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31 and more
7 American Non-Scientific Journals	0.0	0.0	0.0	0.0	14.3	28.6	57.1	0.0	0.0
146 American Scientific Journals	0.0	0.0	0.0	2.1	18.5	49.9	23.3	6.2	0.0
200 Foreign Scientific Journals	1.0	0.5	1.0	6.0	24.5	40.5	18.5	7.0	1.0
200 History Texts	0.0	5.5	27.5	36.5	21.5	7.0	2.0	0.0	0.0
200 Education Texts	0.0	2.0	16.5	38.0	31.0	6.5	6.0	0.0	0.0
200 Psychology Texts	0.0	6.0	20.5	42.5	25.0	3.0	3.0	0.0	0.0
200 Economics Texts	0.5	3.0	13.0	40.5	33.0	8.5	1.0	0.5	0.0
200 Literature Texts	2.0	5.0	20.5	51.0	16.5	4.0	1.0	0.0	0.0

picas. American textbooks, on the other hand, vary between 19 and 24 picas. Here is evidence that publishers regard line width as an important factor in legibility. Thus there is a strong tendency to limit line widths to a narrow range. For magazines, the typical line width is in the neighborhood of 24 picas or about 4 inches, whereas for books the typical line width is approximately 21 picas or about 3½ inches. These figures are closely in line with

the recommendations prevailing since the time of Weber in 1881.

3. Width of Line, Ten Point Type

Study I. In our first experiment we varied line widths between 14 and 44 picas using 10 point type set solid. Unfortunately, we used no control group in this experiment and we unwittingly attributed the differences to the influence of variations in line width. In the light of additional experiments on line width (to be reported in the remainder of this chapter) we are justified in assuming that Test Group I can be used as a control group to supply the correction factor even though the lines of print in Form B were 23 picas, whereas the lines in Form A were 19. As a result of applying this correction, apparently variations in line width between 19 picas and 36 picas have little or no effect on speed of reading (see Table 14). There is a sug-

TABLE 14

Width of Line, Ten Point Type: Study I

Note: Reading speeds for 14, 27, 32, 36, 40, and 44 pica line widths are compared with reading speed for material printed in 19 pica line width as a standard. Ten point type set solid was used throughout. Minus (−) differences indicate slower reading than the standard. Number of readers = 560 college students.

Line Widths	Differences in Per Cent
19 picas vs. 14 picas	−4.1
19 picas vs. 23 picas	0.0
19 picas vs. 27 picas	−2.5
19 picas vs. 32 picas	−2.3
19 picas vs. 36 picas	−3.4
19 picas vs. 40 picas	−5.1
19 picas vs. 44 picas	−7.5

gestion that an unusually short line width (14 picas) may slow up reading to a significant degree. When the line widths reach 40 or more picas, the evidence is clear that reading speed is significantly retarded. We would conclude, therefore, that line widths can vary over a considerable range without any deleterious effects. This conclusion, however, holds only for the conditions prevailing in our first study—namely, when very short paragraphs are used, thus providing a maximum amount of white space between paragraphs and between the broken lines of print. Presumably the six printing unit arrangement would be a far better method to use in studying this factor.

Study II. In our second study we attempted to measure

TABLE 15

Width of Line, Ten Point Type: Study II

Note: Reading speeds for 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, and 27 pica line widths are compared with reading speed for material printed in 19 pica line width as a standard. Ten point type set solid was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 935 college students.

Line Widths	Differences in Per Cent
19 picas vs. 17 picas	+1.1
19 picas vs. 18 picas	+1.9
19 picas vs. 19 picas	0.0
19 picas vs. 20 picas	+2.5
19 picas vs. 21 picas	−3.1
19 picas vs. 22 picas	+0.9
19 picas vs. 23 picas	+3.5
19 picas vs. 24 picas	−0.9
19 picas vs. 25 picas	−2.7
19 picas vs. 26 picas	+0.5
19 picas vs. 27 picas	−1.0

the legibility of minute variations in width of line so we varied the printed material from 17 to 27 picas in steps of one pica each. The results shown in Table 15 indicate that printed material can be varied between these limits without any measurable effect on speed of reading. Again we must keep in mind that the 30 printing unit arrangement was used so that a maximum amount of white space was available.

Study III. In our third study we used the six printing unit arrangement and varied line width by rather large steps from 9 picas to 43 picas. Again 10 point type set solid was used. The results in Table 16 indicate a marked

TABLE 16

Width of Line, Ten Point Type: Study III

Note: Reading speeds for 9, 14, 19, 31, and 43 pica line widths are compared with reading speed for material printed in 19 pica line width as a standard. Ten point type set solid was used throughout. Minus (−) differences indicate slower reading than the standard. Number of readers = 500 high school and college students.

Line Widths	Differences in Per Cent
19 picas vs. 9 picas	−6.7
19 picas vs. 14 picas	−4.2
19 picas vs. 19 picas	0.0
19 picas vs. 31 picas	−6.8
19 picas vs. 43 picas	−6.0

reduction in speed of reading a very short line (9 picas) as compared with the standard (19 picas). There is a suggestion that 14 pica line width retards speed of reading significantly. Longer line widths also appear to retard reading speed (31 and 43 picas). From this study we would conclude that, for 10 point type set solid, the optimal

line width is somewhere in the neighborhood of 19 picas. Presumably it would be safe to vary line widths for 10 point type set solid between 17 and 28 picas. If this conclusion is sound, then it is apparent that the recent tendency for double-column printing to use line widths as short as 12, 13, 14, 15, and 16 picas, is not justifiable so far as the speed factor is concerned.

Study IV. A special study involving the simultaneous variation of line width and leading yields data showing the effect of line widths for 10 point type with two point leading. These data are especially significant since printing practice frequently utilizes 10 point type on a 12 point body. The results shown in Table 17 indicate again that

TABLE 17

Width of Line, Ten Point: Study IV

Note: Reading speeds for 9, 14, 19, 31, and 43 pica line widths are compared with reading speed for material printed in 19 pica line width as a standard. Ten point type, 2 point leading was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 425 college students.

Line Widths	Differences in Per Cent
19 picas vs. 9 picas	−5.3
19 picas vs. 14 picas	+0.3
19 picas vs. 19 picas	0.0
19 picas vs. 31 picas	−2.4
19 picas vs. 43 picas	−5.9

excessively short lines (9 picas) seriously retard speed of reading. Apparently a 14 pica line width is read as rapidly as the standard 19 pica line. This suggests that double-column printing using 14 pica line widths should employ

2 point leading to avoid the retarding effect of such a short line. Likewise, with two point leading, line widths can be increased up to 31 picas without serious losses in legibility. It would not be safe, however, to extend line widths beyond this point since the 43 pica line definitely retards reading speed. This fourth study on line widths suggests that leading is a highly significant factor in legibility, helping to offset the usual disadvantage of relatively short and long line widths with 10 point type.

4. Width of Line, Twelve Point Type

Study I. Our first study of line widths for 12 point type set solid utilized the 30 paragraph arrangement. The results, shown in Table 18, indicate that line widths can be

TABLE 18

Width of Line, Twelve Point Type: Study I

Note: Reading speeds for 17, 21, 23, 25, 27, 29, 33, and 40 pica line widths are compared with reading speed for material printed in 25 pica line width as a standard. Twelve point type set solid was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 760 college students.

Line widths	Differences in Per Cent
25 picas vs. 17 picas	+0.9
25 picas vs. 21 picas	+2.2
25 picas vs. 23 picas	+3.0
25 picas vs. 25 picas	0.0
25 picas vs. 27 picas	+3.2
25 picas vs. 29 picas	+3.5
25 picas vs. 33 picas	+1.6
25 picas vs. 40 picas	+2.7

varied between 17 and 40 picas without any apparent loss in legibility.

Study II. When the six printing unit arrangement was used the results of varying line width from 17 picas up to 41 picas set solid show little or no effect on legibility. These data are shown in Table 19. There is a suggestion,

Table 19

Width of Line, Twelve Point Type: Study II

Note: Reading speeds for 17, 21, 25, 29, 33, 37, 41, and 45 pica line widths are compared with reading speed for material printed in 25 pica line width as a standard. Twelve point type set solid was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 640 college students.

Line Widths	Differences in Per Cent
25 picas vs. 17 picas	+0.2
25 picas vs. 21 picas	+1.9
25 picas vs. 25 picas	0.0
25 picas vs. 29 picas	+1.8
25 picas vs. 33 picas	−2.0
25 picas vs. 37 picas	−1.5
25 picas vs. 41 picas	−5.0
25 picas vs. 45 picas	−4.3

however, that line widths of 41 picas and 45 picas retard reading speed. Apparently, when 12 point type is used, line width within relatively large limits is an unimportant factor in legibility.

Study III. A final study of line width for 12 point type was made in which all the material was printed with two point leading. Again no striking differences in legibility occurred from 17 picas to 41 picas. There is a suggestion that a 41 pica line width exerts an unfavorable influence on speed of reading. An excessively short line (9 picas), however, definitely slows up speed of reading to a marked degree. The results given in Table 20 are thus in harmony

TABLE 20

Width of Line, Twelve Point Type: Study III

Note: Reading speeds for 9, 17, 25, 33, and 41 pica line widths are compared with reading speed for material printed in 25 pica line width as a standard. Twelve point type, 2 point leading was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 450 high school seniors and college students.

Line Widths	Differences in Per Cent
25 picas vs. 9 picas	−5.8
25 picas vs. 17 picas	+0.8
25 picas vs. 25 picas	0.0
25 picas vs. 33 picas	0.0
25 picas vs. 41 picas	−3.5

with the two preceding studies. We would conclude, therefore, that the factor of line width, within large limits, for 12 point type set solid or with 2 point leading is relatively unimportant.

5. Width of Line, Eight Point Type

Study I. When we shift to a study of line widths for 8 point type, the results indicate that line width is unimportant between the limits of 13 and 25 picas. Our first study utilized the six printing unit arrangement and the 8 point type used was set solid. The results, shown in Table 21, indicate quite clearly that a very short line (9 picas) slows up speed of reading to a marked degree and line widths of 29 picas or more likewise retard reading significantly. In spite of these results for relatively short and long lines, there is a range of line widths (13 to 25 picas) which is read equally fast.

TABLE 21

Width of Line, Eight Point Type: Study I

Note: Reading speeds for 9, 13, 17, 21, 25, 29, 33, and 37 pica line widths are compared with reading speed for material printed in 17 pica line width as a standard. Eight point type set solid was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 640 college students.

Line Widths	Differences in Per Cent
17 picas vs. 9 picas	−5.3
17 picas vs. 13 picas	−0.7
17 picas vs. 17 picas	0.0
17 picas vs. 21 picas	+1.2
17 picas vs. 25 picas	−0.9
17 picas vs. 29 picas	−5.6
17 picas vs. 33 picas	−6.0
17 picas vs. 37 picas	−5.8

TABLE 22

Width of Line, Eight Point Type: Study II

Note: Reading speeds for 7, 14, 21, 28, and 36 pica line widths are compared with reading speed for material printed in 21 pica line width as a standard. Eight point type, 2 point leading was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 500 high school seniors.

Line Widths	Differences in Per Cent
21 picas vs. 7 picas	−6.3
21 picas vs. 14 picas	+1.1
21 picas vs. 21 picas	0.0
21 picas vs. 28 picas	−0.5
21 picas vs. 36 picas	−0.4

Study II. Our second study of line width for 8 point type utilized material printed with 2 point leading. The results in Table 22 show that a very short line (7 picas) slows up speed of reading to a marked degree, but that line widths from 14 to 36 picas are read equally fast. It would appear that adequate leading or space between lines tends to reduce the significance of line width as an important factor in legibility. Since our experiments on leading have indicated the general importance of adequate space between lines for moderate and smaller sizes of type we would recommend that printers should pay more attention to the necessity of optimal amounts of leading than to the question of proper line widths.

6. Width of Line, Six Point Type

Study I. Our investigation of line widths for six point type set solid again shows that line widths can be varied between fairly large limits. A glance at Table 23 indicates

TABLE 23

Width of Line, Six Point Type: Study I

Note: Reading speeds for 5, 9, 13, 17, 21, 25, and 29 pica line widths are compared with reading speed for material printed in 13 pica line width as a standard. Six point type set solid was used throughout. Plus (+) differences indicate faster reading than the standard. Number of of readers = 560 college students.

Line Widths	Differences in Per Cent
13 picas vs. 5 picas	−12.3
13 picas vs. 9 picas	−1.7
13 picas vs. 13 picas	0.0
13 picas vs. 17 picas	+0.3
13 picas vs. 21 picas	+1.8
13 picas vs. 25 picas	−2.1
13 picas vs. 29 picas	−4.0

that an excessively short line width (5 picas) and excessively long widths (29 picas or more) definitely slow up speed of reading. However, between 9 picas and 25 picas there are no significant differences.

Study II. In a study of line widths for 6 point type with two point leading (see Table 24) we found that line widths between 14 picas and 28 picas were read with equal facility. Even the short line width of 7 picas and the long line width of 36 picas did not retard speed of reading to any striking degree although it is true that reading speed was slowed up by about 3 or 4 per cent. Again the evidence is clear that as leading is inserted between the lines of print, line width as a typographical factor becomes less important.

TABLE 24

Width of Line, Six Point Type: Study II

Note: Reading speeds for 7, 14, 21, 28, and 36 pica line widths are compared with reading speed for material printed in 21 pica line width as a standard. Six point type, 2 point leading was used throughout. Minus (−) differences indicate slower reading than the standard. Number of readers = 490 high school seniors.

Line Widths	Differences in Per Cent
21 picas vs. 7 picas	−4.1
21 picas vs. 14 picas	−0.1
21 picas vs. 21 picas	0.0
21 picas vs. 28 picas	−1.8
21 picas vs. 36 picas	−3.2

7. Reader Preferences for Line Widths

It was thought advisable to ascertain reader preferences with respect to line widths for 10 point type set solid. The results obtained are clear cut and definite. It is clear that

readers tend to prefer moderate line widths (19 picas). See Table 25. Readers next prefer 14 and 31 pica line

TABLE 25

Widths of Line Ranked According to 224 Reader Opinions of Relative Legibility

(Ten Point Type, Set Solid)

Width of Line	Average Rank	Rank Order
9 picas	4.1	5
14 picas	2.3	2
19 picas	1.7	1
31 picas	2.7	3
43 picas	4.1	4

widths and they least prefer the very short and the very long line widths (9 picas and 43 picas).

8. Summary and Recommendations

1. Most writers on typography emphasize the importance of line width as a typographical factor in legibility, and printing practice tends to confine printed materials to rather narrow limits. Satisfactory experimental studies of line width, however, have not been available to serve as a check on the opinions of writers or as a guide to printing practice. The problem is complicated by the necessity of taking into account the factors of type size and leading. We were forced, therefore, to undertake eleven separate investigations in order to canvass this problem with a reasonable degree of completeness.

2. For 10 point type set solid three studies agree in showing that line widths between 17 and 28 picas are equally legible. Line widths shorter or longer than these limits are undesirable.

3. For 10 point type printed with 2 point leading the limits of "equal legibility" are somewhat larger, ranging from 14 picas to about 31 picas. The findings suggest that double-column printing using line widths as short as 14 picas should utilize 2 point leading in order to maintain maximum legibility.

4. The studies using 12 point type show that line width is relatively unimportant. This is true whether the material is set solid or is set with 2 point leading. The evidence indicates that line width can vary from 17 to 41 picas without any apparent loss in legibility.

5. For eight point type set solid, line widths ranging from 13 to 25 picas are equally legible. When 8 point type is leaded 2 points the range of equally legible line widths extends from about 13 picas to 36 picas.

6. Two studies of 6 point type indicate that line widths can be varied between 9 and 28 picas without apparent loss of legibility. This is true for material set solid as well as for material set with 2 point leading.

7. In all of the studies for 8 and 10 point type the evidence is quite consistent in indicating that line widths can be extended without loss of legibility for material leaded 2 points as compared with material set solid.

8. None of the above findings verify or justify Kleppner's definite recommendations in regard to appropriate line widths for various sizes of type.

9. Reader preferences appear to favor moderate line widths. Printing practice, generally speaking, is thus shown to be adjusted to the desires of the average reader.

Chapter 5

Size of Type in Relation to Width of Line

1. Introduction

THERE is a common belief that small type should be printed in a short line width and large type should be printed in a long line width. This belief assumes that these two factors, when varied together, will promote maximum efficiency in reading for each size of type. This viewpoint is expressed by Kleppner when he states, "To make the advertisement easy to read, the lines should not be set too wide for a given size of type."[1] He even goes so far as to give in the appendix of his book a table showing recommended widths of line for each of seven sizes of type.

Strangely enough no previous experimenter, with the exception of Gilliland,[2] has worked on this problem. He varied size of type and line width by photographically enlarging and reducing a standard short paragraph which had been set in 12 point type with a 20 pica line width. Since photographic enlargement and reduction does not duplicate printing conditions, it is apparent that the practical significance of his findings is necessarily limited. Thus it is obvious that definite evidence should be secured in order to determine the best relationship between size of type and width of line.

[1] *Op. cit.*, pp. 228 and 523.

[2] A R. Gilliland, "The Effect on Reading of Changes in the Size of Type." *El. School J.*, 1923, 24, 138-146.

2. Printing Practice

Our survey of printing practice indicates that publishers and printers do not have definite opinions on the question at issue. The diversity of practice that exists is revealed clearly in Table 26. In this table we have tabulated the

TABLE 26

Survey of Printing Practice with Reference to Line Widths Used for Different Sizes of Type

Size of Type	Line Widths in Picas 11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29 and above	Total
9		12	5	6	3	11	8	4	4	1	54
10	3	22	14	30	54	122	129	95	48	16	533
11		1	4	13	81	175	120	95	33	7	529
12		3	3	20	81	120	68	19	12	2	328
										Grand Total	1444

frequency of use of line widths for 9, 10, 11, and 12 point type sizes, lumping together the various kinds of printing covered in our survey.[3] The table includes only 1444 of the 1500 specimens surveyed, because we eliminated from consideration 56 specimens that were printed in unusually large or small type sizes. For 9 point type there is no common practice with reference to preferred line widths, the line widths ranging from 13 picas to 29 picas or more. The same statement is equally true for 10, 11, and 12 point type. There is a suggestion, however, that when 10

[3] Scrutiny of Table 13 will reveal that single-column journals tend to use longer line widths than textbooks; hence, lumping both together will show an apparent greater diversity of printing practice. Since Tables 13 and 26 reveal an apparent inconsistency, we conclude that printing practice in its use of line width varies with the *kind* of printing (journal vs. textbook) rather than with size of type.

6 point, 16 picas

28. On Sunday Mr. Jones never reads anything but good books for he is a very religious man. Each

8 point, 17 picas

28. On Sunday Mr. Jones never reads anything but good books for he is a very religious man. Each

10 point, 19 picas

28. On Sunday Mr. Jones never reads anything but good books for he is a very religious man. Each

12 point, 23 picas

28. On Sunday Mr. Jones never reads anything but good books for he is a very religious man. Each

14 point, 27 picas

28. On Sunday Mr. Jones never reads anything but good books for he is a very religious man. Each

FIG. 9. Simultaneous variation of type size and line width, Scotch

point type is used, publishers tend to use a 21 to 24 pica line width. When 11 point type is used the trend is toward a 21 or 22 pica line width, and the same is true for 12 point type. At any rate diversity of practice is apparent with no tendency to increase width of line for the larger type sizes. If there be an optimal line width for each size of type it is apparent that publishers do not follow it in their printing practice.

3. Legibility of Type Size and Line Width

We proceeded to investigate this problem by accepting a 19 pica line width as being optimal for 10 point type (see Chapter IV). We instructed the printer to set up the reading tests in 6, 8, 10, 12, and 14 point type, but to vary line width by following a *line for line* printing procedure. By doing this the following line widths were obtained: 16, 17, 19, 23, and 27 picas respectively for the type sizes listed above (see Figure 9). The resulting printing *areas* involved differed one from the other by large amounts as may be seen from the following:

Type Size and Line Width	Outside Measurements (In millimeters)	Area (In sq. mm.)
6 pt., 16 picas	144 x 147	21,168
8 pt., 17 picas	152 x 187	28,424
10 pt., 19 picas	170 x 228	38,760
12 pt., 23 picas	202 x 265	53,530
14 pt., 27 picas	236 x 309	72,924

In view of the fact that the *area* differences are so great one might anticipate that speed of reading would be retarded markedly as one moves from the small print and short line to the larger type sizes and longer line.

At least this would be so if the reading is affected materially by the ground to be covered by the eyes in reading

the material on the printed page. The results of our experiment, involving 400 readers, are shown in Table 27. A glance at the table shows that there is no direct relation

TABLE 27

Simultaneous Variation of Size of Type and Width of Line

Note: Reading speeds for 6, 8, 10, 12, and 14 point type with 16, 17, 19, 23, and 27 pica line widths respectively are compared with reading speed for material printed in 10 point type and 19 pica line width as a standard. All material was set solid throughout. Minus (−) differences indicate slower reading than the standard. Number of readers = 400 college students.

Type Size and Line Width	Differences in Per Cent
10 pt., 19 picas vs. 6 pt., 16 picas	−6.0
10 pt., 19 picas vs. 8 pt., 17 picas	−0.6
10 pt., 19 picas vs. 10 pt., 19 picas	0.0
10 pt., 19 picas vs. 12 pt., 23 picas	−3.1
10 pt., 19 picas vs. 14 pt., 27 picas	−3.3

between variation in size of type and width of line on the one hand and speed of reading on the other. As a matter of fact, 8 point type—17 pica line width, and 10 point type—19 pica line width, are read equally fast and both are read more rapidly than the larger and the smaller sizes. The evidence is clear-cut that a type size as small as 6 point, even when printed in a shorter line width, is very illegible. It slows down reading speed at least 6 per cent. The larger sizes of type, however, are not as inefficient as the 6 point. Both 12 and 14 point type retard speed of reading somewhat (3.1 per cent and 3.3 per cent, respectively). Thus the results show that reading speed bears little or no direct relationship to area of reading material,

i.e., the smallest area is not read faster than the largest area.

From a theoretical point of view, the results obtained in this experiment suggested that a reduction in size of type from 10 point to 6 point is sufficient to produce illegibility and thus markedly retard one's speed of reading. Presumably, printed words and phrases when so small are difficult to grasp. This difficulty disappears when 8 or 10 point type is used. When a still larger type is reached, a different kind of difficulty enters the picture. It would seem that the larger *area*, requiring far more ground to be covered per word and phrase, is the factor that is responsible for slowing up the speed with which this material can be grasped.

4. Summary

This experiment yields evidence that neither size of type nor line width, as separate factors, can be relied upon as final determinants of legibility. Both factors (and perhaps others as well) work hand in hand and must be properly balanced to produce a printed page which will promote a maximum reading rate. For this reason we would again emphasize the necessity of exercising caution in drawing conclusions in regard to the effect of type size or line width on reading speed. The reader should continue to suspend judgment, pending detailed presentation of the effects of variations in type size, line width and leading which appears in Chapter VII.

Chapter 6

Leading

1. Opinions and Previous Experiments

"LEADING has been disputed almost as hotly as any other typographical question," is the way Pyke[1] summarizes expressions of opinion on this subject. He points out that nine writers insist that leading enhances legibility, one writer is uncertain, whereas three believe that leading is unimportant.

In our previously mentioned correspondence with publishers in regard to styles of type faces are found a number of unsolicited comments on the importance of leading. Some appeared to believe that leading is so important that our proposed experiment on type faces would be worthless unless we set up our printed materials with a certain amount of leading. Quotations from some of these letters will reflect the emphasis placed upon interlinear spacing:

1. "Another point upon which the writer has a very distinct opinion is that the legibility of a printed page is increased greatly by adequate spacing between lines. A smaller faced type with double or triple leads is often much more readable than a larger type set solid. In fact the setting of distinctly large type without proper leading tends greatly to illegibility."
2. "Incidentally, you say you are planning to print your different pieces of text in 10 point. We hope that this

[1] *Op. Cit.*, p. 16.

means '10 on 11 point'—that is to say, 10 point type with one point space between lines. Solid 10 point does not make for legibility and the leading, we believe, would make the experiment a truer one."

3. "As regards the matter of legibility, a great deal of that has to do with the spacing between lines, . . . and not altogether the style or the face of the type."
4. "It might be of interest to you to know that we normally use a two-point leading in our books; that is ten-point is set on a twelve-point body, eleven-point on a thirteen-point body, etc."

These quotations reveal a genuine concern as to the importance of leading but also a lack of agreement as to just how much leading is necessary to affect legibility.

As a "horrible" example of the kind of advice offered the printing industry we quote the following table of leading recommendations:[2]

Type Size	Minimum Leading	Maximum Leading
6 point	Solid	1 point
8 point	Solid	2 point
10 point	Solid to 2 point	4 point
11 point	1 point	4 point
12 point	2 point	6 point
14 point	3 point	8 point

It is apparent that Sherbow believes that leading is unimportant with the smaller sizes of type but becomes increasingly important as the size of type increases.

In spite of positive opinions about the importance of leading no effective experiments exist to provide a safe guide to printing practice.[3] Griffing and Franz found a slight increase in legibility when leading was introduced.

[2] Benjamin Sherbow quoted in *The Legibility of Type*, Brooklyn: Mergenthaler Linotype Company, 1935, p. 14.

[3] For references cited, see D. G. Paterson and M. A. Tinker, "Space Between Lines or Leading." *J. Appl. Psychol.*, 1932, 16, 388-397.

Bentley also found that leading increases legibility. Both of these studies, however, failed to duplicate ordinary reading situations. Their results would seem to apply more directly to the billboard, car-card, and poster type of printing. Hovde, who limited his study to newspaper typography, found no consistent effect of leading on speed of reading but the variations of leading used were confined to quarter points from material set solid to 1 point. His inconclusive results may be due merely to the restricted range of leadings employed, although there is reason to believe that his general method was faulty.

The above studies constitute a meager foundation of knowledge with respect to a typographical factor considered by many to be of prime importance. It is evident that adequately controlled experiments on the effect of leading will contribute useful information.

2. Printing Practice

Our survey of printing practices included the item of leading. The results as shown in Table 28 reveal a marked tendency to utilize 2 point leading. Apparently there is greater uniformity among printers in the use of a given amount of leading than in the use of a given type size. From one-half to two-thirds of the journals and textbooks use 2 point leading. From one-fifth to one-fourth employ 1 point leading or set solid. Only 10 to 20 per cent use in excess of 2 point leading. The results are quite different when attention is focused upon the non-scientific journals and magazines where only 23 per cent use 2 point leading, 44 per cent use 1 point leading and the remaining third have the material set solid. Leading in excess of 2 points simply does not appear in the non-scientific magazine field.

TABLE 28

Survey of Printing Practice with Reference to Leading

Note: Results are given in terms of percentage distributions.

	Amounts of Leading in Points					
	0	1	2	3	4	5
100 American Non-Scientific Journals	33.0	44.0	23.0	0.0	0.0	0.0
200 American Scientific Journals	13.0	14.0	68.5	4.5	0.0	0.0
200 Foreign Scientific Journals	10.5	14.0	61.5	10.5	3.5	0.0
200 History Texts	6.5	19.0	50.0	15.0	8.0	1.5
200 Education Texts	5.0	18.5	65.0	8.5	3.0	0.0
200 Psychology Texts	3.5	17.0	61.5	11.0	7.0	0.0
200 Economics Texts	5.0	20.0	63.0	6.0	6.0	0.0
200 Literature Texts	4.0	22.0	52.0	13.5	8.0	0.5

At first thought one might believe that the diversity of practice revealed in Table 28 is due to a careless massing of statistics on leading irrespective of size of type and width of line. In other words, one could argue that printers adopt an optimal amount of leading in accordance with type size and line width. Such is not the case, however. Our original tabulations and statistical summaries took these two factors into consideration. We can testify, therefore, that line width is not at all related to amount of leading used, whereas type size is only slightly related to amount of leading. In regard to this last point we noticed a slight tendency for material printed in 10 point to be set solid, but the majority of 10 point type printing actually uses 2 point leading. We also noticed a slight tendency for material printed in 12 point type to be set with larger amounts of leading.

Our survey of printing practice in the use of leading

indicates that printers believe that it greatly increases the legibility of print. But because of the diversity of practice it would be difficult to predict just what the relation is between various amounts of leading and reading speed. Hence, there is urgent need for detailed experiments.

3. Leading with Ten Point Type

In our first experiment on leading we measured the effectiveness of various amounts of leading when used with 10 point type (see Figure 10). For this first study our test

Set solid

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and

1 point leading

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and

2 point leading

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and

4 point leading

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and

Fig. 10. Set solid to 4 point leading for Scotch Roman, 10 point.

forms were printed in 10 point, Scotch Roman, 19 pica line width on eggshell paper stock. Leading differences were as follows: set solid, 1 point, 2 point, and 4 point leading. Four test groups of 100 college students each were used for the four degrees of leading investigated. The results are reported in Table 29.

TABLE 29

Leading or Interlinear Space for Ten Point Type

Note: Reading speeds for 0, 1, 2, and 4 point leading are compared with reading speed for material set solid as a standard. Ten point type, 19 pica line width was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 400 college students.

Leading	Differences in Per Cent
Set solid vs. set solid	0.0
Set solid vs. 1 point leading	−1.0
Set solid vs. 2 point leading	+5.2
Set solid vs. 4 point leading	+2.8

Our findings indicate that 1 point leading contributes nothing to legibility. This result will come as a distinct shock to those printers who have been in the habit of inserting 1 point leads or of using 10 point type on an 11 point body with the notion that they were thereby increasing legibility. Apparently, to bring about a definite increase in legibility it is necessary to introduce 2 point leading. Strangely enough, a further increase in leading beyond 2 point is not beneficial. In fact, 4 point is very little better than set solid. Thus for 10 point type with a 19 pica line width the optimal amount of leading is fixed at 2 point.

With such clear-cut results available the modern printer could easily recommend the general desirability of 2 point leading. But the conscientious printer would have to limit such a recommendation to instances where 10 point type is to be used. He could not be sure that the recommendation would apply to material set up in larger or in smaller type. To meet the need for facts regarding leading for

larger and for smaller sizes of type it was natural for us to push our investigations in these two directions.

4. Leading with Twelve Point Type

The study of the effect of leading with 12 point type required us to print our test form in 12 point, Scotch Roman, 25 pica line width on eggshell paper stock. The 25 pica line width was chosen as being more in harmony with the requirements of 12 point type than the 19 pica line width which had been found appropriate for 10 point type. In this study six variations of leading were used because we thought that larger type might show important effects of increased amounts of leading. Amounts of leading, therefore, were chosen as follows: set solid, 1 point, 2 point, 4 point, 6 point, and 8 point. The results are reported in Table 30.

Our hunch as to the possible effect of increased amounts of leading for an increased size of type proved to be false.

Table 30

Leading or Interlinear Space for Twelve Point Type

Note: Reading speeds for 0, 1, 2, 4, 6, and 8 point leading are compared with reading speed for material set solid as a standard. Twelve point type, 25 pica line width was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 570 college students.

Leading	Differences in Per Cent
Set solid vs. set solid	0.0
Set solid vs. 1 point leading	−2.3
Set solid vs. 2 point leading	+1.8
Set solid vs. 4 point leading	+0.4
Set solid vs. 6 point leading	+0.7
Set solid vs. 8 point leading	+0.3

Not only did we fail to find that increased leading is important for 12 point type, but to our amazement we discovered that leading is a factor of little or no importance here. In other words 12 point type set solid is read as fast as 12 point type leaded.

The leading experiments with 10 point and with 12 point type show how dangerous it is to generalize from one printing arrangement to another. What is true for 10 point type may be wholly false in dealing with 12 point type. The necessity of working out "rules" for various sizes of type complicates enormously the problem of discovering optimal printing arrangements. For this reason, the laborious work of checking on each typographical factor in a variety of printing arrangements must be carried out systematically if printers are to have reasonably accurate rules to guide practice.

5. Leading with Eight Point Type

The discovery that leading is unimportant for 12 point type naturally raises the question as to its effects on type sizes smaller than 10 point. Our experiment using 8 point Scotch Roman type with a 17 pica line width printed on eggshell paper stock utilized six groups of 84 college students each. Again leading differences ranged from set solid to 8 point interlinear spacing. The results in Table 31 show quite clearly that even small amounts of leading are effective in speeding up the reading process. Furthermore, no definite advantage arises from increased amounts of leading beyond 2 point. It is true that 2 point leading appears to be slightly better than 1 point but the advantage is not only slight but also is somewhat uncertain. From the point of view of printing practice, therefore, speed of reading is definitely increased when 1 or 2 points of lead-

TABLE 31

Leading or Interlinear Space for Eight Point Type

Note: Reading speeds for 0, 1, 2, 4, 6, and 8 point leading are compared with reading speed for material set solid as a standard. Eight point type, 17 pica line width was used throughout. Plus (+) differences indicate faster reading than the standard. Number of readers = 504 college students.

Leading	Differences in Per Cent
Set solid vs. set solid	0.0
Set solid vs. 1 point leading	+5.0
Set solid vs. 2 point leading	+5.8
Set solid vs. 4 point leading	+1.9
Set solid vs. 6 point leading	+3.0
Set solid vs. 8 point leading	+4.9

ing are inserted in material printed in 8 point type with a moderate line width.

6. Type Size versus Leading

The reader will recall that the first quotation cited at the beginning of this chapter contained this statement: "A smaller faced type with double or triple leads is often much more readable than a larger type set solid." Kleppner in his chapter on "The Advertisement in Print" shares this point of view and even goes so far as to specify the exact relationship.[4] He states, "A page of 10-point set solid, for instance, is far more difficult to read than a page of 8-point type set on a 10-point body, that is, with 2-point leading between each line." This claim at first sight, seems plausible. In view of the fact that this generalizaion is derived from a rich experience in the publishing and advertising

[4] *Op. Cit.*, p. 228.

fields we undertook an experiment with the expectation that the claim would be substantiated. We compared speed of reading 10 point type set solid with speed of reading 8 point type with 2 point leading. The results, as shown in Table 32 definitely indicate that these two printing arrangements are equally legible. In other words, the claim

TABLE 32

Type Size versus Leading

(10 pt. solid vs. 8 pt. with 2 pt. leading)

Note: Reading speeds for 8 point type with 2 point leading and 10 point type set solid are compared with reading speed for material printed in 10 point type set solid as a standard; 19 pica line width was used in both groups. Plus (+) differences indicate faster reading than the standard. Number of readers = 200 high school seniors.

Type Size and Leading	Differences in Per Cent
10 pt. set solid vs. 10 pt. set solid	0.0
10 pt. set solid vs. 8 pt., 2 pt. leading	+1.0

that leading will make a smaller sized type more legible than a larger sized type set solid is found to be false. In view of the fact, however, that 10 point type is more legible than 8 point type other things being equal as shown in Chapter III, the present experiment may be accepted as additional proof of the value of 2 point leading for 8 point type. Thus both size of type and leading are important factors in typography. The best results are achieved when optimal leading goes along with optimal type size. It is high time for printers to cease pinning their faith to one factor as against another. Efficiency demands the search for, and the use of, optimal combinations of factors.

7. Opinions of Readers Regarding Leading for Ten Point Type

We submitted samples of 10 point printing set solid and leaded 1 point, 2 points, and 4 points to 224 readers with the request that the samples be ranked in order of relative legibility. The results, shown in Table 33, indicate quite clearly a definite preference for 2 point leading. Material printed with 1 point leading is ranked as a close second, whereas 4 point leading is ranked in third place and material set solid is ranked in fourth place. The evidence suggests that readers believe that leading is advantageous for speedy reading. Thus readers tend to agree with printers and publishers in regard to leading as a factor of advantage in legibility.

TABLE 33

Degrees of Leading Ranked According to 224 Reader Opinions of Relative Legibility

Degrees of Leading	Average Rank	Rank Order
Set solid	3.1	4
1 point	2.2	2
2 point	2.0	1
4 point	2.7	3

8. Leading in Relation to Type Size and Line Width

Complete knowledge of the effects of leading in relation to legibility requires that the influence of various amounts of leading be studied in connection with variations in type size and line width. The facts concerning leading reported in the preceding paragraphs may be accepted as established and printing specifications may well be based upon these

findings. One cannot generalize, however, from these specific findings. Indeed, we have repeatedly demonstrated how dangerous it is to generalize. For this reason, we advise the reader to suspend judgment in regard to the effects of leading when type sizes and line widths are systematically varied. Our experiments in which all three factors are studied in combination will be found in the next chapter.

9. Summary and Recommendations

1. For 10 point type set in a 19 pica line width, 2 point leading is optimal. One point leading is not advantageous and the practice of using 10 point type on an 11 point body should be abandoned.

2. For 12 point type set in a 25 pica line width, leading is not advantageous. From the point of view of unit costs, therefore, 12 point type when used should be set solid.

3. For 8 point type set in a 17 pica line width, 1 point leading is distinctly advantageous. Two point leading also speeds up reading but is no better than one point leading.

4. The notion that a smaller sized type leaded would be better than a larger sized type set solid was found to be false. Specifically, it appears that 10 point type set solid is read just as rapidly as 8 point type with 2 point leading. Since reader preference favors 10 point solid as against 8 point type leaded, the former should be used.

5. Since the influence of leading varies according to size of type, the reader should consult Chapter VII for evidence in regard to leading when line width and type size are varied together.

and approximately 10,000 readers were tested. The detailed results follow.

We believe that the facts reported in this chapter will provide the printing industry with guide-posts that have long been needed. We present the findings so that the practical printer, the advertising agency man, the publisher, and all others who write printing specifications will be able to consult the tables in this chapter as a constant guide in their daily work.

2. Ten Point Type

In setting up the study of leading variations combined with line width variations for 10 point type, we used, as a standard, test material printed in 19 pica line widths with 2 point leading. The line width variations and the leading variations shown in Table 34 were each compared in turn with the standard, the differences being shown as percentage increases or decreases in speed of reading. For

TABLE 34

Simultaneous Variation of Line Width and Leading for
TEN POINT TYPE

Note: Reading speeds for 9, 14, 19, 31, and 43 pica line widths each set solid and leaded 1 point, 2 points, and 4 points are compared with reading speed for Scotch Roman printed in 19 pica line width leaded 2 points as a standard. Minus (–) differences indicate slower reading than the standard. Figures in bold face indicate extremely unsatisfactory typographical arrangements. Number of readers = 1760 college students.

Line Width	Set Solid	1 Point Leading	2 Point Leading	4 Point Leading
9	**−9.3**	**−6.0**	**−5.3**	**−7.1**
14	**−4.5**	−0.6	−0.3	−1.7
19	**−5.0**	**−5.1**	0.0	−2.0
31	**−3.7**	−3.8	−2.4	−3.6
43	**−9.1**	**−9.0**	**−5.9**	**−8.8**

example, the test material printed in a 9 pica line width, set solid was read 9.3 per cent more slowly than the standard, whereas the test material printed in the same short line width with 1 point leading was read 6.0 per cent more slowly than the standard. Other entries in the table are to be interpreted in a similar manner. One should note that one cannot read horizontally across the table for a given line width, or vertically down the table for a given amount of leading and directly compare the magnitude of the percentages. The difference between any two percentages does indicate the relative speeds with which any two arrangements were read, but the interpretation is a matter of inference. For example, the 9 pica line width set solid and the 9 pica with 1 point leading were read 9.3 and 6.0 per cent more slowly than the standard. It is obvious that the material set solid was read more slowly than the material with 1 point leading, but the difference in the two percentages does not mean that the material set solid was read 3.3 per cent more slowly than the material with 1 point leading.

Examination of Table 34 shows that the region of optimal legibility ranges between a 14 pica line width with 1 point leading or more to a line width somewhat under 31 picas. It is to be noted that 2 or 4 point leading must be used with 19 pica line width to produce optimal legibility. Presumably, a printer can specify line widths within this range, if leading is used, with assurance that maximum legibility will be maintained. Apparently shorter line widths or longer widths leaded or solid fall in the region of poor legibility.

On the assumption that a 4 or 5 per cent decrease in legibility is sufficiently pronounced to warrant avoidance in printing practice, we have indicated all such differences

in the table by the use of **bold face type**. The result permits one readily to identify the zone of safety and the zone of danger.

3. Eleven Point Type

The results for 20 variations in line width and leading for 11 point type are shown in Table 35. A glance at the

TABLE 35

Simultaneous Variation of Line Width and Leading for
ELEVEN POINT TYPE

Note: Reading speeds for 7, 16, 25, 34, and 43 pica line widths each set solid and leaded 1 point, 2 points, and 4 points are compared with reading speed for Granjon printed in 25 pica line width leaded 2 points as a standard. Minus (–) differences indicate slower reading than the standard. Figures in bold face indicate extremely unsatisfactory typographical arrangements. Number of readers = 1900 high school seniors.

Line Width	Set Solid	1 Point Leading	2 Point Leading	4 Point Leading
7	**−11.2**	**−9.0**	**−12.2**	**−10.2**
16	**−4.7**	−0.6	−0.8	−3.3
25	−0.7	+0.7	0.0	−1.4
34	−2.5	−0.1	−1.6	−2.6
43	**−6.4**	**−4.7**	−3.5	−2.8

table is sufficient to show that the zone of safety covers a far greater area than was true for 10 point type. Apparently the shift from 10 point to 11 point type permits the use of a larger variety of line widths without loss of legibility. The optimal limits range from a 16 pica line width leaded to a 34 pica line width leaded 1 or 2 points. Interestingly enough, 11 point type with a 25 pica line width is read equally fast set solid or leaded. Line widths from about 20 picas to about 30 picas can be used with the material set solid without loss of legibility.

The recent trend toward the use of 11 point type would

seem to be justified not only on the grounds that it is more legible than 10 point type but also because it permits greater flexibility in line width and leading specifications. Thus the printer who uses 11 point type need avoid only excessively short lines and excessively long lines.

4. Twelve Point Type

The results for 12 point type also clearly indicate that the larger the type the less the importance of line width and leading as factors in legibility. The fact that Table 36

TABLE 36

Simultaneous Variation of Line Width and Leading for
TWELVE POINT TYPE

Note: Reading speeds for 9, 17, 25, 33, and 41 pica line widths each set solid and leaded 1 point, 2 points, and 4 points are compared with reading speed for Scotch Roman printed in 25 pica line width leaded 2 points as a standard. Minus (−) differences indicate slower reading than the standard. Figures in bold face indicate extremely unsatisfactory typographical arrangements. Number of readers = 1800 high school seniors and college freshmen.

Line Width	Set Solid	1 Point Leading	2 Point Leading	4 Point Leading
9	**−7.4**	**−6.0**	**−5.8**	**−5.0**
17	−2.6	−0.9	+0.8	−0.9
25	−0.8	−2.5	0.0	+2.4
33	−2.7	−0.7	0.0	+2.1
41	**−8.1**	−3.7	−3.5	−3.5

contains only 5 bold face entries is evidence that the zone of danger is limited to only very short line widths (9 picas) and very long line widths set solid (41 picas). In other words, an amazing variation in line width is possible without diminution in legibility. Surprisingly enough, leading cuts no figure at all in affecting legibility from 17 pica line widths to and including 33 pica line widths. Lead-

ing seems to have an important effect only for excessively long lines (41 picas) where it definitely counteracts the detrimental effect on legibility. With the very short line (9 picas) leading has only a slight beneficial effect.

It is apparent that stepping up the size of type from 10 point to 11 point and to 12 point brings about an increase in the zones of safety. This suggests that as type size increases the factors of line width and leading become less and less important. This is fortunate because it gives the printer greater leeway with reference to these two factors when he adopts a type size as large as 12 point. For example, if 12 point is used, some saving in space (unit printing cost) can be effected by printing the material set solid with a moderate line width without loss of legibility.

5. Eight Point Type

When we drop back to 8 point type the results, as shown in Table 37, also indicate a surprisingly large zone

TABLE 37

Simultaneous Variation of Line Width and Leading for
EIGHT POINT TYPE

Note: Reading speeds for 7, 14, 21, 28, and 36 pica line widths each set solid and leaded 1 point, 2 points, and 4 points are compared with reading speed for Scotch Roman printed in 21 pica line width leaded 2 points as a standard. Minus (–) differences indicate slower reading than the standard. Figures in bold face indicate extremely unsatisfactory typographical arrangements. Number of readers = 2000 high school seniors.

Line Width	Set Solid	1 Point Leading	2 Point Leading	4 Point Leading
7	**−9.6**	**−6.8**	**−6.3**	**−8.6**
14	−1.0	−2.9	+1.1	−1.9
21	−2.5	−2.5	0.0	+1.0
28	**−6.3**	−1.0	−0.5	−1.7
36	**−5.2**	**−4.9**	−0.4	−0.3

of safety. Here we find that optimal legibility extends from 14 pica line width set solid to 28 pica line width leaded 1 or more points and to 36 picas leaded 2 or more points. There is a suggestion in these figures that as we depart from 10 point type in the direction of larger or smaller type we find a larger variety of optimal arrangements possible. It looks as though the safety zone is small for 10 point type and is greater for larger and for smaller type sizes.

6. Six Point Type

For the smallest type size investigated, 6 point, we again find a relatively large safety zone. The safe limits, as shown in Table 38 range from 14 pica line width set

TABLE 38

Simultaneous Variation of Line Width and Leading for
SIX POINT TYPE

Note: Reading speeds for 7, 14, 21, 28, and 36 pica line widths each set solid and leaded 1 point, 2 points, and 4 points are compared with reading speed for Scotch Roman printed in 21 pica line width leaded 2 points as a standard. Minus (–) differences indicate slower reading than the standard. Figures in bold face indicate extremely unsatisfactory typographical arrangements. Number of readers = 1960 high school seniors.

Line Width	Set Solid	1 Point Leading	2 Point Leading	4 Point Leading
7	**−6.4**	**−4.5**	**−4.1**	**−6.5**
14	−1.9	−3.4	−0.1	−0.1
21	−3.3	−0.9	0.0	−0.4
28	**−5.5**	−3.9	−1.8	−1.3
36	**−9.9**	**−7.0**	−3.2	−3.7

solid through 28 picas leaded and 36 picas leaded 2 or more points. These results fall in line with the trend noted for type sizes larger and smaller than 10 point.

In the interpretation of Table 38 it is to be noted that a more conservative view can be taken. We refer to the fact that we have included all differences under 4 per cent as indicating equally legible printing arrangements. If one regards a 3 per cent loss in legibility as undesirable then one would proceed to restrict the safety zones to narrower limits. This is true for all of the tables discussed so far in this chapter.

On the whole, it appears that leading plays an important role in minimizing the poor legibility effects of long and short line widths. If it were not for the beneficial effects of leading the printer would be confined to a much smaller range of line widths in his attempts to produce legible print.

7. Cautions on Interpretation

The reader is cautioned not to compare directly the findings presented above for the various type sizes. The results hold only for a given type size and give no information in regard to the relative legibility of the various type sizes. It is for this reason that the reader interested in relative legibility of type sizes should consult the chapter on type size.

8. Summary and Recommendations

As a result of the extensive investigations reported in this chapter we are able to present in outline form the principal findings. These are formulated positively by directing attention to what we have termed "safety zones" for each type size. By "safety zone" we mean the limits of variation in line width and leading that may be utilized for a given type size without serious loss of legibility.

Safety Zones for Commonly Used Type Sizes:

6 Point: 14 picas set solid through 28 picas leaded and 36 picas leaded 2 or more points.

8 Point: 14 picas set solid through 28 picas leaded and 36 picas leaded 2 or more points.

10 Point: 14 picas 1 or more points leading, to a line width somewhat under 31 picas, with the exception that 2 or 4 point leading should be used with a 19 pica line width.

11 Point: 16 picas leaded to a 34 pica line width leaded 1 or 2 points.

12 Point: 17 picas set solid to 33 picas leaded 1 or more points.

9. Relative Legibility of Six Sizes of Type

Having determined the optimal line widths and amounts of leading for 6, 8, 10, 11, and 12 point type sizes, we undertook a final study concerning the relative legibility of these type sizes each leaded 2 points and printed in an optimal line width. We also included 9 point type size in the series for completeness.

The results are presented in Table 38a. A glance at the table is sufficient to show that 9, 10, 11, and 12 point are all equally legible when each is printed in an appropriate line width with 2 point leading. According to these results, 8 point type appears to retard speed of reading slightly (3.4 per cent). Speed of reading is seriously retarded, however, when 6 point type is used (5.0 per cent).

These results are in contrast with the facts presented in Table 11 in which line width was constant at 19 picas for all type sizes. The present study clearly shows the advantages inherent in optimal line widths with 2 point leading for various type sizes. In other words, the printer should

TABLE 38A

Relative Legibility of 6, 8, 9, 10, 11, and 12 Point Type

Note: Reading speeds for 6, 8, 9, 10, and 12 point type are compared with reading speed for 11 point type as the standard. Each type size was printed in an optimal line width as shown below. Granjon type face was used with 2 point leading. Minus (−) differences indicate slower reading than the standard. Number of readers = 504 college students.

Type Size and Line Width	Differences in Per Cent
11 pt., 22 picas vs. 6 pt., 14 picas	−5.0
11 pt., 22 picas vs. 8 pt., 16 picas	−3.4
11 pt., 22 picas vs. 9 pt., 18 picas	−0.3
11 pt., 22 picas vs. 10 pt., 20 picas	−1.7
11 pt., 22 picas vs. 11 pt., 22 picas	0.0
11 pt., 22 picas vs. 12 pt., 24 picas	+1.0

follow the zones of safety in Tables 34 to 38 in using any given size of type.

Chapter 8

Spatial Arrangements of the Printed Page

IN THIS chapter we shall consider such factors as: 1. size of full page; 2. size of printed portion of the page; 3. margins (top, bottom, outside and inside); 4. single-column versus double-column composition; 5. space and lines between columns; and 6. paragraphing arrangements.

1. Size of Full Page

So far as the writers are aware, no evidence exists in regard to the relation between size of page and legibility. Presumably, the size of page adopted for any particular piece of printing is a matter of practical and esthetic judgment. Since experiments seem to be out of the question, one must resort to a survey of printing practice to determine whether or not publishers and printers are in agreement with reference to desired page sizes. If practical considerations of economy or if esthetic considerations reflect decisions that have been proved to be of lasting value, then one would expect to find general agreement in regard to usage.

In our survey of printing practice we included a measurement of page size. The results are shown in Table 39. It is obvious at a glance that each of the general classes of printing surveyed tends to have characteristic page sizes. The textbooks tend to fall into three groupings, i.e., 4 x 7, 5 x 7, and 5 x 8 inches. Foreign scientific journals show

TABLE 39

Survey of Printing Practice with Reference to Size of Full Page

Note: Results are given in terms of percentage distributions.

Width and Height of Page in Inches	1000 Text Books	200 Foreign Science Journals	200 American Science Journals	100 American Non-Science Journals
4 x 6	2.4	0.0	0.0	0.0
4 x 7	28.0	0.5	1.0	0.0
4 x 8	0.3	0.0	1.5	0.0
5 x 5	0.1	0.0	0.0	0.0
5 x 6	0.1	0.0	0.0	0.0
5 x 7	27.8	0.5	0.0	1.0
5 x 8	29.9	20.0	6.0	2.0
5 x 9	5.8	8.0	9.0	3.0
5 x 10	0.0	0.0	0.5	0.0
6 x 8	0.9	1.0	0.5	0.0
6 x 9	4.6	59.5	32.0	15.0
6 x 10	0.0	4.5	26.5	2.0
7 x 8	0.0	0.5	0.0	0.0
7 x 9	0.1	0.0	3.5	0.0
7 x 10	0.0	3.5	15.0	7.0
7 x 11	0.0	0.5	1.5	5.0
8 x 10	0.0	0.0	1.0	3.0
8 x 11	0.0	0.5	1.5	41.0
8 x 12	0.0	0.5	0.5	5.0
9 x 11	0.0	0.0	0.0	1.0
9 x 12	0.0	0.5	0.0	3.0
9 x 13	0.0	0.0	0.0	2.0
10 x 13	0.0	0.0	0.0	8.0
10 x 14	0.0	0.0	0.0	1.0
11 x 14	0.0	0.0	0.0	1.0

a greater scatter, there being four groupings, i.e., 5 x 8, 5 x 9, 6 x 9, and 6 x 10. The American scientific journals show still more scatter with six groupings, i.e., 5 x 8, 5 x 9, 6 x 9, 6 x 10, 7 x 9, and 7 x 10. The American non-scientific journals show the greatest scatter of all with a concentration at 8 x 11 and a number of smaller groupings, i.e., 6 x 9, 7 x 10, 7 x 11, 8 x 12, and 10 x 13. This is in

spite of the fact that our survey did not include the small pocket sizes such as *Readers Digest* which is 5½ x 7½ inches.

The above tabulations give the appearance of a general agreement as to desirable page sizes. But the agreement is more apparent than real. As a matter of fact, it was necessary to group page sizes in coarse units of one inch in order to keep the table within manageable limits. Within these one-inch units, scarcely any agreement was discernible. For example, the 27.8 per cent of textbooks listed as being 5 x 7 were distributed evenly over a large number of intervals differing from each other by only one-sixteenth inch in either height or width. In fact, when one looks at the detailed tabulations lying behind the summary presented in Table 39, one is impressed with what appears to be a studied effort on the part of each publisher or printer to put out his book or magazine in a page size that is unique. One is forced to conclude that neither practical considerations nor esthetic ones dominate the choices. It almost looks as though the size of page is a matter of whim.

All of these facts suggest the desirability of having publishers, printers and paper stock manufacturers arrive at an agreement on page sizes that would minimize the waste of paper stock that must now occur in the printing of many books and magazines. It would appear that the movement for standardization in industry begun during World War I should be extended to include the printing and publishing industry.

2. Size of the Printed Page

We made a similar survey of printing practice with respect to size of the printed page. A similar striking diver-

sity of printing practice was found. Since the size of the printed page is based upon decisions with respect to size of full page, height of top and bottom margins, and width of line, it is clear that our actual measurements of printed page sizes can have little meaning or value. Consequently, we omit the details but merely report the fact of diversity. Standardization agreements, of course, would necessarily include desirable limits in size of the printed page in relation to the full page.

3. Margins

Pyke's review shows that no one has attempted to determine the effect of varying margin widths on legibility. In spite of the dearth of facts, however, we find positive opinions expressed by various writers. Cohn in 1883 asserted his preference for margins but failed to specify how wide they should be. Dearborn reported himself to be strongly in favor of margins because he believed that the wider the margin, the more peripheral color stimuli would be kept out. The Committee of the American School Hygiene Association advanced the argument, "the margin should be sufficient so that the eye in the backward movement does not *swing off* the paper." The British Committee likewise declared itself in favor of margins by stating that good margins are restful and worth what they cost. But the opinions are not unanimous since one of the earliest authorities (Weber, 1881) insisted that margins are superfluous.

Strangely enough, contemporary authorities on printing seldom say anything about a use to which outer margins were put in the earlier days of printing. We refer to the printing of marginal notes as a device to assist the reader to comprehend the text proper. As printers developed in-

creasing confidence in the ability of readers to comprehend the printed text the use of marginal notes disappeared. One suspects that this process was gradual and that printers merely eliminated the marginal notes without readjusting the width of outer margins. Thus practical reasons for wide outer margins led to a practice that still persists even though the original reason no longer prevails. This is the history of most traditions.

Most of the discussion on margins is concerned with recommendations in regard to the need of an adequate inner margin, sometimes called back margin or gutter margin. It is pointed out that this margin should be wide enough so that the inner end of the line of print is not obscured by the curvature of the paper.

Recommendations in regard to top or head, bottom or foot, and outer or side margins are frequently made but are couched in the vaguest sort of language. The most definite recommendation we have seen is that of Jacobi (1912) who argues that the inside margin should be narrowest, top margin should be next in width, outer margin should be next, and the bottom margin the widest.

Manuals of style approach the problem of margins from the point of view of total page size (paper page) and the proportion of the full page that should be occupied by the type on the page. The rule for page size dates from the early days of printing when the size was determined by the number of folds in the sheets used. Since sizes of paper vary, printing practice itself varies as may be seen from our survey of printing practice given at the beginning of this chapter.

Having dealt with the subject of page size in an indefinite manner, the style manuals proceed to assert that the type on the page should occupy 50 per cent of the total

page and the proportions of the dimensions of the two should be identical.

We were curious to find out whether or not printers actually follow the style manuals in specifying that 50 per cent of the total page should be devoted to margins. Our detailed measurements of page sizes and margin sizes for different kinds of printing permitted us to make the necessary calculations. We computed for each of 400 textbooks (200 history texts and 200 literature texts) the ratio of printed area to the area of the full page. The numerical and percentage distributions of these ratios are shown in Table 40. The smallest ratio found was .29. This means that only

TABLE 40

Numerical and Percentage Distributions of Ratios of Printed Page to Full Page for 400 Textbooks

Note: Ratio obtained by dividing the area of the printed page by the area of the full page. The median ratio is .528.

Ratio	Number	Per Cent
.73–.76	2	0.50
.69–.72	2	0.50
.65–.68	9	2.25
.61–.64	30	7.50
.57–.60	47	11.75
.53–.56	106	26.50
.49–.52	95	23.75
.45–.48	67	16.75
.41–.44	26	6.50
.37–.40	11	2.75
.33–.36	3	0.75
.29–.32	2	0.50
Total	400	100.00

29 per cent of the total page was devoted to printed material. In other words, in this book 71 per cent of each page

was devoted to margins. At the other end of the distribution of ratios two books were found in which the percentage of full page devoted to printing reached as high as 76. In these books only 24 per cent of each page was devoted to margins. The average book (median) devoted 52.8 per cent of the full page to printing and 47.2 per cent to margins. In other words, although there is diversity in practice, printers, on the average, come pretty close to following the 50 per cent white space rule.

In discussing the 50 per cent rule with numerous individuals, we discovered that none of them was aware of the rule and when asked to guess the typical ratio in the average book, the estimates ran well over 50 per cent. In other words, these readers believed that a large proportion of a book page is devoted to printed matter and only a small proportion to margins.

In view of the fact that printers follow the 50 per cent rule in practice and that readers are not aware of this, it would seem that a psychological illusion exists. To determine the existence of such an illusion we proceeded, systematically, to question 928 student readers. Each of these student readers submitted his estimate in response to the following: "You are requested to indicate your best estimate or guess as to: With reference to the typical textbook or book of fiction I estimate that the percentage of the total page space devoted to the main body of printed material (the rest of the page is composed of margins) is ———." These estimates were then tabulated and the results are presented in Table 41. It is obvious that the overwhelming majority of these student readers believe that 60 per cent or more of the total page is devoted

TABLE 41

Distribution of Estimates in Regard to Percentage of Total Page Space Devoted to Printed Material

Note: 928 college students submitted the estimates.

Percentage of Total Page Devoted to Printed Material	Number	Percentage
90–100	53	5.7
80– 89	240	25.9
70– 79	292	31.5
60– 69	238	25.6
50– 59	71	7.7
40– 49	16	1.7
30– 39	8	0.9
20– 29	6	0.6
10– 19	4	0.4
0– 9	0	0.0
Total	928	100.0

to printed matter. The most frequent estimate is in the neighborhood of 75 per cent. In other words, the average reader believes that three-fourths of the printed page is devoted to printing and that only one-quarter is devoted to margins. This is an illusion effect of about 25 per cent since actual practice follows the 50 per cent rule, whereas readers believe that a 75 per cent rule is followed.

To test experimentally the existence of this illusion one of our students, Miss Dorothy Plain, obtained estimates of the proportions of center areas to total card areas (black centers on white backgrounds and white centers on black backgrounds) for different sizes of cards involving a graded series of proportions (see Figure 11). She found that her 300 subjects overestimated the center area in relation to total card area on the average by 18 per cent. These results prove the existence of a part-whole proportion illu-

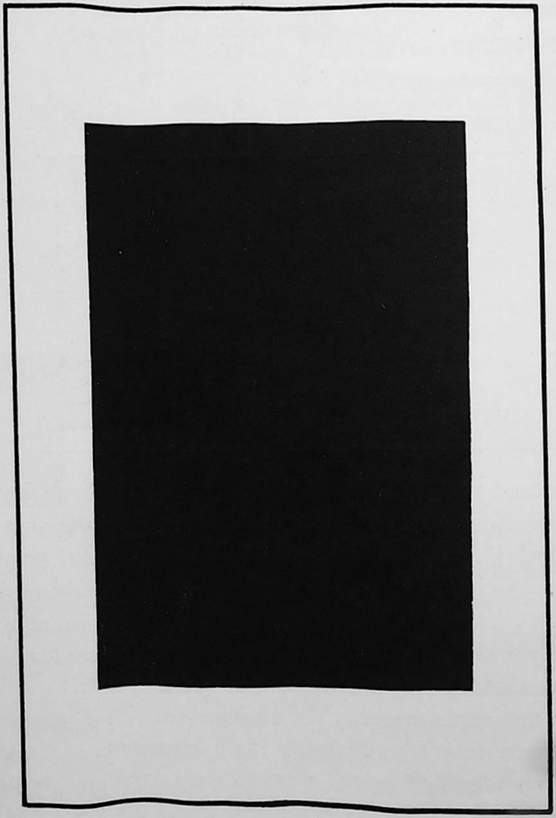

FIG. 11. Part-whole proportion illusion. The black area is 50% of the total area although it appears to occupy 68% of the total area.

sion which undoubtedly affects reader judgments of the printed page.[1]

As soon as the estimates, presented in Table 41, were made and collected, the students were given the following statement:

"The general rule followed by publishers is to devote 50 per cent of the total page to white space in the margins.

"Some people believe that it is necessary to devote 50 per cent of the page to white space in order to give the page a pleasing appearance.

"Others believe that this amount of white space in margins is necessary to promote legibility which is ease and speed of reading.

"Still others believe that the rule should be followed because it has long been a tradition of the printing industry.

"Finally, there are those who believe that the rule is not justified because it increases the cost of books."

The following questionnaire was then passed out with the request that each student should check the one statement with which he most nearly agreed:

"The practice of devoting 50 per cent of the printed page to white space is (check one):

( ) A. Justified because it gives the page a pleasing appearance

( ) B. Justified because white space surrounding printed material is necessary to promote legibility

( ) C. Justified because it has long been a tradition of the printing industry

( ) D. Not justified because it increases the cost of books."

The results of this questionnaire are shown in Table 42. The majority of the students (62.0 per cent) believe that

[1] D. G. Paterson and M. A. Tinker, "The Part-Whole Proportion Illusion in Printing." *J. Appl. Psychol.*, 1938, 22, 421-425.

TABLE 42

Summary of Beliefs of Student Readers in Regard to Justification for the Fifty-Fifty Rule for Printed Material and Margins in Book Composition

The Practice of devoting 50 per cent of printed page to white space is:	Number Checking	Percentage Checking
A. Justified on esthetic grounds	251	27.1
B. Justified because of legibility	575	61.9
C. Justified because of tradition	16	1.7
D. Not justified because of cost	86	9.3
Total	928	100.0

the 50 per cent rule is justified because of legibility requirements. Only 27.1 per cent justified the rule on esthetic grounds. Very few believe that tradition justifies the rule. Finally, 9.3 per cent do not believe that the practice is justified since it increases the cost of books.

It is apparent that readers believe margins are an important factor in legibility. In other words, from the reader's point of view, margins must justify themselves on the basis of efficiency rather than esthetics. For this reason it is important to determine the extent to which margins actually promote legibility.

The 50 per cent rule is secured by specifying that the width of the type page should be .71 of the width of the total page and the height of the type page should be .71 of the height of the total page.

The horizontal position of the type page is determined by having the outside margins appear equal to the inner margins, treating the two facing pages as a unit. This means that each outer margin should equal the two inner margins taken together. The unsatisfactory character of this rule is tacitly admitted by calling attention to the

necessity of breaking the rule to counteract the curvature of the paper in the gutter margins. One, therefore, proceeds to make the inner margins as much wider as the "trained eye" believes necessary, due consideration being given not only to legibility but also to esthetic proportion. This leaves the decision to caprice. No wonder printing practice shows such great diversity!

The vertical position is determined mechanically by a clever procedure which provides that the type page should be centered on a diagonal of the total page drawn from the inner top (center of the two-page unit) to the outer bottom corner. This means that the upper inner corner and the lower outer corner of the type page should be on the diagonal. Of course, one is instructed to deviate from this position as much as is necessary to produce a pleasing effect.

According to these rules the width of the bottom margin takes care of itself. The result is that in most books the bottom margin is unnecessarily wide.

From the printer's point of view, the whole subject of margins is thus seen to be primarily a matter of esthetics achieved by artistic deviations from mechanical rules and mathematical proportions. Most writers merely perpetuate these notions without considering the possibility of introducing innovations. Thus the heavy hand of tradition continues to dominate printing practice. We would be iconoclastic enough to question at the outset a rule that commits the printing industry in perpetuity to a 50 per cent waste of expensive paper space for all book printing. Can we be absolutely certain that a 50 per cent waste of available space is essential to a pleasing appearance? In all phases of art esthetic values shift from time to time. For this reason we do not see how anyone can justify the rule of 50 per cent waste by an appeal to any immutable principle of art.

This being so, we believe that it is high time for printers and publishers to consider the factors of legibility and financial cost in addition to esthetics in determining page sizes and margin sizes.

Our survey of printing practice included detailed measurements of margin widths to a sixteenth of an inch. This permitted us to determine the *relative* sizes of the four margins as well as their *absolute* widths. The results of both kinds of measurement are shown in Tables 43 and 44.

TABLE 43

Survey of Printing Practice with Reference to Relative Widths of the Four Margins

Note: Results are given in terms of percentage distributions.

Rank Order	Kind of Printing	Inside	Top	Outside	Bottom
1	1000 Textbooks	0.7	9.8	0.8	88.9
	100 Am. Non-Sci. Jour.	10.0	26.0	7.0	52.0
	200 Am. Sci. Jour.	6.0	17.0	1.5	74.0
	200 For. Sci. Jour.	3.5	24.5	1.0	71.0
2	1000 Textbooks	5.3	80.4	3.9	9.4
	100 Am. Non-Sci. Jour.	19.0	44.0	14.0	28.0
	200 Am. Sci. Jour.	16.5	60.5	5.5	20.5
	200 For. Sci. Jour.	9.0	66.5	1.5	23.0
3	1000 Textbooks	54.6	8.1	37.9	1.4
	100 Am. Non-Sci. Jour.	39.0	21.0	31.0	16.0
	200 Am. Sci. Jour.	56.5	15.5	23.5	5.0
	200 For. Sci. Jour.	63.5	7.5	26.0	4.0
4	1000 Textbooks	39.3	1.7	57.4	0.3
	100 Am. Non-Sci. Jour.	32.0	9.0	48.0	4.0
	200 Am. Sci. Jour.	21.0	7.0	69.5	0.5
	200 For. Sci. Jour.	24.0	1.5	71.5	2.0

Table 43 shows for the four kinds of printing the rank order of widths for the four margins. The table is to be

TABLE 44

Survey of Printing Practice with Reference to Widths of Margins in Inches

Note: Results are given in terms of percentage distributions.

	Less Than 7/16	7/16 to 9/16	10/16 to 12/16	13/16 to 15/16	16/16 to 18/16	More Than 18/16
A. 1000 Textbooks						
Inner margin	5.2	34.0	48.2	11.2	1.1	0.3
Top margin	2.2	29.6	49.0	16.5	2.0	0.7
Outer margin	0.1	3.4	19.8	32.4	29.5	14.8
Bottom margin	0.2	0.4	5.6	19.9	25.1	48.5
B. 100 Am. Non-Sci. Jour.						
Inner margin	15.0	31.0	37.0	15.0	2.0	0.0
Top margin	4.0	29.0	42.0	21.0	3.0	1.0
Outer margin	1.0	16.0	39.0	24.0	16.0	14.0
Bottom margin	1.0	9.0	30.0	26.0	19.0	15.0
C. 200 Am. Sci. Jour.						
Inner margin	4.0	18.0	31.0	18.5	24.0	4.5
Top margin	1.0	6.0	23.5	29.0	19.5	21.0
Outer margin	0.0	4.5	12.0	22.0	20.0	41.5
Bottom margin	0.0	2.0	3.5	15.5	22.0	57.0
D. 200 For. Sci. Jour.						
Inner margin	1.0	18.5	41.5	29.5	9.0	0.5
Top margin	0.5	7.0	31.0	33.0	20.0	8.5
Outer margin	0.0	0.0	3.5	16.5	45.0	35.0
Bottom margin	0.0	0.0	3.5	8.0	27.5	61.0

read as follows: for 88.9 per cent of 1000 textbooks the bottom margin was the widest (rank order 1). For 9.8 per cent of these same textbooks the top margin was widest and for a negligible percentage (0.7 and 0.8) the inside and the outside margins were widest. For 80.4 per cent of the textbooks the top margin was the next to the widest (rank order 2) with a scattering for the remaining margins. Rank orders 3 and 4 tend to be divided between the inside and outside margins for the textbooks with a slight

tendency for the inside margin to be wider than the outside margin.

The data for non-scientific and scientific magazines tend to approximate that for the textbooks although there is less uniformity in the relative widths of the margins.

To sum up, it is apparent that there is a general tendency for the bottom margin to be widest, for the top to be next, the inside to be next and the outside margin to be narrowest. This order does not conform to the recommendations made by Jacobi in 1912.

Because of the marked diversity of printing practice in regard to the relative widths of margins it is instructive to scrutinize the actual measurements of the four margins shown in Table 44. This table shows the percentage distribution of the actual measurements for each margin for the four kinds of printing included in our survey. For example, the inner margins of 1000 textbooks vary from less than seven-sixteenths inch to more than one and two-sixteenths inches. Similar diversity is shown for the other margins and for all kinds of printing. In fact, the outstanding characteristic of Table 44 is diversity. None of the percentages is high enough to indicate even an approach to uniformity.

Of course, it is true that page sizes vary and one could argue that diversity in margin sizes is merely a result of such differences in page size. The problem does not seem important enough to warrant detailed analysis of margin sizes in relation to page size. There is every reason, however, to believe that factors other than mere page size are at work. Book stylists undoubtedly differ among themselves with reference to margin measurements that are pleasing to the "trained eye." The effort to impress the reader with the bulkiness of a short manuscript also plays

a role. We refer to the "padding" of books and magazines to make the reader believe he is getting his money's worth. It is no secret that large type, heavily leaded, and wide margins are devices used to make a book or magazine look impressively large. When one realizes that it is the generally accepted rule to sell a reader 50 per cent white space, it borders on the unethical to stretch the material so that 60 or 70 per cent or more of the page is blank paper. No wonder some consumers feel that the cost of printed matter is too high!

Our experiment on the relation between margins and legibility was a simple one devoted to the single question: Is material printed with a right and left margin read more rapidly than material printed without a margin at the ends of the lines of print?

One would expect that such margins would promote legibility if the views of various writers on the psychological aspects of the topic are accepted. Dearborn favored margins because he believed peripheral color stimuli (color of desk or other background) would produce a reflex effect diminishing accuracy of fixations. He claimed that the wider the margin the more such peripheral color stimuli would be kept out. The American School Hygiene Committee emphasized the importance of wide margins so that the eye in the backward movement will not *swing off* the paper. Walter, in his admirable book on printing, quotes a Mr. Loren H. Carter as follows, "Top margin has but one function, to 'fence in' the attention when the top line is being read. The side and gutter margin must confine the attention repeatedly, as we read from line to line." All these views are based on theories in regard to mechanical devices presumed necessary to control eye movements. If these theories and the beliefs of our student readers (Table

42) be correct, then our experiment should show a definite advantage in favor of right and left margins.

The results of our experiment are shown in Table 45 and, surprising though it may be, no advantage in favor of margins is apparent. As a matter of fact, the material

TABLE 45

Margin versus No Margin

Note: Reading speed for material printed with ⅞ inch margin right and left of lines of print is compared with reading speed for material printed without a margin (actually a $\frac{1}{16}$ inch margin was employed right and left). Ten point type, Scotch Roman, 19 pica line width, 2 point leading, single-column composition was used in both arrangements. Plus (+) difference indicates faster reading than the standard. Number of readers = 190 college students.

Printing Arrangement	Differences in Per Cent
⅞ inch margin versus ⅞ inch margin	0.0
⅞ inch margin versus no margin	+1.9

printed with no margin was read slightly faster but not significantly so. Our conclusion is that margins do not promote greater legibility. Here is another instance where speculations in regard to eye movements turn out to be without foundation.

Since margins are not essential from the point of view of legibility, and since they add greatly to costs, it is clear that they must be justified, if justified at all, solely in terms of esthetics.

4. Single-Column vs. Double-Column Composition

Experiments on the legibility of single-column composition versus double-column composition are unnecessary

since the problem reduces itself to one involving the legibility of the line widths. For this reason we attempted no special test of the relative legibility of single-column versus double-column composition. In dealing with this question, therefore, we refer the reader to the evidence already reported in earlier chapters on optimal line widths for different sizes of types. In addition, we present the results of our survey of printing practice concerning single-column versus double-column composition and also a special study of reader preferences.

Our survey of 500 magazines and 1000 textbooks indicates that double, triple, and quadruple-column composition are restricted to American scientific and American non-scientific journals. The results are shown in Table 46. When more than two columns are used, it is obvious that it is confined to the large flat type of magazine. It is important to note that only 7 per cent of American non-scientific magazines employ single-column composition. We assume that the tendency for non-scientific magazines to utilize double or triple-column composition is based on financial considerations of economy in printing as well as

TABLE 46

Survey of Printing Practice with Reference to Single-Column versus Multiple-Column Composition

Note: Results are given in terms of percentage distributions.

Kind of Printing	Single-Column	Double-Column	Triple-Column	Quadruple-Column
100 Am. Non-Sci. Jour.	7.0	60.0	32.0	1.0
200 Am. Sci. Jour.	73.5	26.0	0.5	0.0
200 Foreign Sci. Jour.	97.5	2.5	0.0	0.0
1000 Textbooks	99.8	0.2	0.0	0.0

on the desire to have available large display space for full-page advertisements and to make possible the continuation of reading material into the advertising section to accommodate less than full-page ads.

It is interesting to note that over one-quarter of the American scientific journals use double-column composition. This trend is fairly recent and reflects an effort to effect printing economies as well as to get away from long printed lines believed to be hard to read. It is probable that a larger and larger percentage of scientific journals will follow this trend. The figures cited in Table 46 are for journals printed in 1931-32. We made a survey of 166 American scientific journals published in 1936 as compared with the same journals printed in 1931 and found that 9 additional journals had adopted the double-column arrangement whereas only two had gone back to the single-column.

The advantages of double-column composition for a scientific magazine are many. In the first place, more words can be printed on a larger page with a subsequent saving in total margin area per 100 words. There is a saving also with respect to composition costs of running heads. A further saving arises from the more economical use of space devoted to printing cuts, tables, and formulas. For example, many cuts, tables, and formulas can be confined to one of the columns without reduction of legibility. Another advantage of double-column composition is that relatively large tables and cuts and lengthy formulas can be printed across both columns whereas in a single-column arrangement it might be necessary to print the cuts and tables sidewise or to print the formula on two lines which breaks up its unity. Double-column composition will also avoid the necessity of "tipping in" large tables and cuts,

although there is a limit beyond which double-column printing will not accommodate large tables and cuts.

The considerations listed above apply with equal force to book printing and may lead publishers of textbooks in the future to adopt double-column composition.

Whenever the question of single-column versus double-column composition is discussed one will find positive opinions expressed in favor of one or the other arrangement. It would appear to be wise to avoid acrimonious debate among the few persons usually involved in such decisions by finding out what opinions are held by groups of readers. To ascertain such reader opinions, we submitted samples of single-column and double-column composition to 241 readers. Our two samples were taken from *Psychological Abstracts* at a time when single-column composition was used and at a time when double-column composition was used. We made zinc etchings from the journal and printed our samples from these etchings. Each reader looked at each sample and decided which printing arrangement he would prefer to read. The results show that 60.5 per cent preferred the double-column arrangement whereas only 39.5 per cent favored the single-column page.

Presumably, persons directly concerned with the printing industry would tend to agree among themselves more closely than the readers we sampled. We were fortunate in being able to repeat the study with 38 typography experts and printers, attending a regular meeting of the Minneapolis Society of Printing House Craftsmen. To our amazement the division of opinion in this group was precisely the same, to wit, 60.5 per cent preferred the double-column page and 39.5 per cent preferred the single-column. When experts disagree among themselves, it would seem wise to resort to the general reader. In this case, both

sources of information point to a general preference for double-column arrangement.

5. Space and Rules Between Columns

In double-column composition, the problem of preventing confusion in reading is solved either by the use of inter-column rules or by the use of white space. In newspaper printing inter-column rules are almost always employed. In magazine printing inter-column rules are extremely rare. These printing practices suggest agreement as to the necessity of inter-column rules when columns are crowded as in newspaper composition and the undesirability of such rules when adequate space is available as in magazine printing. As a matter of fact, the soundness of these two principles appears so self-evident as not to require proof. But experimental science has long since discovered that what appears to be self-evident need not be true. Hence, these two principles as well as all other typographical features should be put to an experimental test. This we have done.

Before presenting the results of our experiments we shall give a report of our survey of printing practice. We confined our survey to 51 American scientific journals and 57 American non-scientific magazines published in 1936 with two or more column composition. In only one of these 108 publications was an inter-column rule employed. Since inter-column space was used almost universally, we are interested in discovering the precise amount of white space utilized to separate the columns. For the scientific journals, a one pica inter-column space is used in 49 cases, one-half pica space in one case, and one and one-half picas in another case. In other words, practically all scientific journals use a one pica space. For the non-scientific maga-

Rule with no space between columns

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

¼ pica on each side of rule

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

½ pica on each side of rule

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

½ pica space between columns

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

1 pica space between columns

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

2 pica space between columns

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

16. This band of men and women set sail for the new world where they could live in peace. There

zines, a greater diversity of practice exists. Eight use one-half pica space, thirty-four use one pica, ten use one and one-half picas, and five use two picas.

Very little information on space and rules between columns is to be found in the literature on typography. Pyke's survey includes only two references. The British Committee Report[2] on government printing in 1922 recommended that no inter-column metal rules should be used, reliance being placed on white spaces only. Legros,[3] in the same year, favors a slightly wider margin where a metal rule would otherwise be considered necessary, stating "a white space should logically form the boundary between adjacent areas of print." It is evident that there is need for experimental tests of this whole question.

Figure 12 shows the variations we employed in testing the effect of inter-column rules and different amounts of white space on legibility. Merely looking at these samples would lead most printers to jump to the conclusion that the use of an inter-column rule *without any white space* would seriously retard speed of reading. Many would also believe thas the use of only a one-half pica white space without a rule would be inadequate. It would seem reasonable to suppose that the eyes in reading these kinds of materials would tend to "jump across" to the next column and thus slow up reading time.

The actual results are quite contrary to such views as is shown in Table 47. In fact, the evidence contained in Table 47 flatly contradicts prevailing notions. The eyes

[2] Report of the Committee on the Best Faces of Type and Modes of Display for Government Printing, London, Stationery Office, 1922, pp. 18.

[3] L. A. Legros, "Note on the Legibility of Printed Matter." Published by the Committee on Type Faces, London, Stationery Office, 1922, pp. 17.

TABLE 47

Inter-Column Spaces and Rules

Note: Reading speed for ½ pica space, 1 pica space, rule with ½ pica space on each side, rule with ¼ pica space on each side, and rule with no space is compared with reading speed for 2 pica inter-column space without rule as a standard. Minus (−) differences indicate slower reading than the standard. Number of readers = 480 college students.

Space and Rules between Columns	Differences in Per Cent
2 pica space versus ½ pica space	+0.5
2 pica space versus 1 pica space	−0.2
2 pica space versus 2 pica space	0.0
2 pica space versus rule with ½ pica space on each side	−1.4
2 pica space versus rule with ¼ pica space on each side	+0.2
2 pica space versus rule without space	−1.4

simply refuse to behave the way we would naturally expect them to. All inter-column arrangements employed in this experiment were found to be equally legible.

Our 224 readers gave first rank to the practice of separating columns by the use of a rule with one-half pica space on each side (see Table 48). Yet this practice is

TABLE 48

Inter-Column Arrangements Ranked According to 224 Reader Opinions of Relative Legibility

Space and Rules between Columns	Average Rank	Rank Order
½ pica space	4.5	5
1 pica space	2.7	3
2 pica space	2.5	2
Rule, ½ pica each side	2.1	1
Rule, ¼ pica each side	3.8	4
Rule, no space	5.4	6

rarely found in either scientific or non-scientific magazines. Our readers are also agreed in selecting a two pica

space or a one pica space as being next in efficiency. The other three arrangements employed in our study are ranked quite low.

It is interesting, therefore, to note that printers are not meeting reader preference in favor of a rule with one-half pica space or a two pica space without a rule. Printing practice, however, does not run entirely contrary to reader preference since readers do rank the one pica space arrangement relatively high. It is possible that readers rank three of the arrangements low because of unfamiliarity since printing practice does not use any of them.

6. Paragraphing Arrangements

It is universal practice to separate "thought units" mechanically by indenting the first line of every paragraph. This is called regular indentation. Thus a *plain* paragragh has the first line indented and the other lines flush.

So far as the writers are aware the effect of paragraphing on speed of reading has never been measured. It so happens that in our series of experiments, we were able to measure this factor although our measurement was a by-product rather than an attempt directly to measure the effects of a universal printing practice.

The reader will recall that our test materials as originally set up consisted of 30 paragraphs of 30 words each. Paragraph arrangements for such brief "thought units" necessarily introduced far more white space than is ordinarily found on a printed page. This fact made it difficult for us to investigate such typographical factors as leading and line width. It was necessary, therefore, to re-arrange the page composition so as to approximate the usual appearance of the printed page. This was accomplished by throwing five paragraphs into a given "paragraph composition

unit." This meant that our new six printing unit arrangement gave the appearance of six paragraphs although the same thirty "thought units" were retained.

We then proceeded to measure speed of reading these two contrasting arrangements. The results for 180 college students indicated that the six printing unit arrangement was read 7.3 per cent more slowly than the 30 paragraph arrangement. Had we printed all 30 paragraphs continuously without any breaks at all, it is probable that the retardation in rate of reading would have been even greater than 7.3 per cent. Thus the practice of separating thought units by regular indentation justifies itself in terms of legibility.

Dearborn, in 1906, following a suggestion by Dr. Cattell, put forward the idea that legibility might be improved by indenting every other line at the left. He stated: "A small indentation of a few millimeters, for example of every other line, but not of sufficient extent to affect the uniformity of the horizontal movement, or even the length of line itself, may be of a distinct advantage in eliminating motor inaccuracies in the vertical plane. The indentation would help to differentiate the lines, and prevent their confusion" (p. 39). It is obvious that Dearborn was thinking of the desirability of utilizing a mechanical device to increase the accuracy with which the eyes would fixate the beginning of each succeeding line on the return sweep. Huey, in his book on reading, mentioned with approval this idea.

So far as we know, only one investigator has put the idea to an experimental test and this was in a specialized kind of reading. We refer to Baird's experiments designed to improve the legibility of telephone directories. He found that indenting every other line in a telephone directory in-

creased only slightly the speed and accuracy of locating telephone numbers. As a matter of fact, leading was far more efficacious than indenting.

The results of our own experiment are shown in Table 49. It is quite clear that indenting every other line is det-

TABLE 49

Indentation of Alternate Lines

Note: Reading speed for material with alternate lines of print indented one pica at the left is compared with reading speed for material printed in a regular manner as a standard. Ten point type, Scotch Roman, 19 pica line width, set solid and printed on eggshell paper stock was used in both arrangements. Minus (−) difference indicates slower reading than the standard. Number of readers = 538 college students.

Printing Arrangement	Differences in Per Cent
Regular printing versus regular printing	0.0
Regular printing versus indentation of alternate lines	−3.4

rimental rather than advantageous. Such indentation retards reading speed 3.4 per cent. Although this degree of retardation is not great, nevertheless, the fact that retardation results from the indentation of alternate lines proves that Cattell, Dearborn, and Huey were wrong in suggesting possible advantages. Our results thus confirm the wisdom of printing all lines flush at the left, except, of course, at the beginning of each paragraph.

7. Summary and Recommendations

1. Our survey of printing practice showed that the page sizes of textbooks tend to be 4 x 7, 5 x 7, and 5 x 8 inches. Within each of these sizes, however, there is a great diversity.

2. American scientific journals show still greater diversity, the majority falling into the following page sizes: 5 x 8, 5 x 9, 6 x 9, 6 x 10, 7 x 9, and 7 x 10 inches.

3. Foreign scientific journals also show scatter in page sizes, to wit, 5 x 8, 5 x 9, 6 x 9, and 6 x 10 inches.

4. The American non-scientific journals show the greatest diversity of all, varying from small pocket sizes to large flat magazines.

5. It is recommended that publishers, printers, and paper stock manufacturers arrive at an agreement on page sizes that would minimize the waste of paper stock that must now occur in the printing of books and magazines in such a large variety of page sizes.

6. Printing practice shows that, on the average, the area of printed matter occupies 50 per cent of the total page size. Readers are not aware of this fact because of the existence of a part-whole proportion illusion. Our experiments show that material printed without any margin at all is read just as rapidly as material having the usual large margin. It is clear, therefore, that a great saving in the printing of books and magazines could be made by dispensing to a large degree with marginal space.

7. Single-column printing characterizes textbooks and foreign scientific journals. American non-scientific journals, however, tend to be printed in double, triple and even quadruple-column arrangements. There is a definite trend toward the use of the double-column arrangement in American scientific journals. Readers and typography experts tested by us prefer, by a ratio of 3 to 2, the double-column printing to single-column composition.

8. In view of our findings in regard to type size, line width, and leading together with the finding that margins are a costly luxury, and the further fact that double-

column printing is actually preferred, we would be bold enough to recommend that scientific journals and even textbooks should be printed in double-column composition with very slight margins. The saving would not only be in paper stock but also in the composition of running heads and the possibility of printing more economically large tables and graphs without the necessity of tipping them in. We suspect that the widespread adoption of this recommendation would eventually be welcomed by librarians who are finding it more and more difficult to provide the necessary linear shelving for the ever increasing number of books they must store.

9. Performance reading tests show that six possible inter-columnar arrangements are all equally legible. This means that a rule between columns without any space is just as legible as a two pica space between columns. In fact, the latter is no more legible than a one-half pica space between columns. Printers generally use one pica space between columns. Since one-half pica space between columns is just as legible, here is another way printing costs can be reduced. It is true, however, that readers prefer a rule with one-half pica space on each side.

10. The practice of separating "thought units" by the indentation of the beginning of each paragraph was found to speed up reading rate significantly.

11. A suggestion by reading experts that the indentation of every other line of print might improve legibility was found to be false. As a matter of fact, such indentation retards speed of reading and therefore should be avoided except, of course, at the beginning of each paragraph.

Chapter 9

Black Print versus White Print

SPEED of reading black print on white paper as compared with white on black is of relatively small interest to the printing industry as a whole, yet it does arise as an important problem in the field of advertising. Were it not for the practical difficulties of printing white on black, a zinc etching being necessary, it is probable that this arrangement would find wider use in advertising practice as a device for attracting attention because of its novelty. The advertiser, however, wishes to know how much loss in speed of reading occurs when he uses white print on black background as an attention-getting device. The advertiser also wishes to know the relative perceptibility at a distance of these two kinds of printing. For definite knowledge on these two points, it is natural for the advertiser to turn to the psychological laboratory.

Unfortunately, the information on these two questions contained in standard textbooks on typography and the psychology of advertising is not only meagre but also unsatisfactory. For the most part the available information is based upon inadequate experimentation or reflects mere opinion. To remedy this situation the Psychology Laboratory at the University of Minnesota undertook several extensive investigations.

1. Legibility in the Ordinary Reading Situation

The advertiser's interest in the relative legibility of black print on white background versus white on black arises from the use of text material in the body of advertisements appearing in newspapers, magazines, booklets and circulars. Before an advertiser proceeds to lay out an advertisement calling for white on black in the text he should know the amount of loss in legibility involved in such copy. Otherwise, the advertiser may unwittingly so decrease the legibility of his advertisement as to offset any attention-getting advantage gained by the novelty effect of white on black.

The only direct evidence available on the question at issue is given by Daniel Starch in his 1914 text on advertising.[1] He prepared two pieces of reading material alike in all respects except that one was printed with black on white and the other with white on dark gray. When these two pieces of reading material were read by forty persons the results showed a 42 per cent advantage in favor of black on white. The findings, however, are greatly reduced in significance because of the small number of readers and the author's failure to describe completely important features of the experimental conditions. In addition to these criticisms it must be kept in mind that the results throw no light upon the specific question before us since Starch employed white on dark gray rather than white on black.

In our experiment we measured the speed of reading our test materials when printed black on white and white on black. For both arrangements we used zinc etchings and

[1] D. Starch, *Advertising,* Chicago: Scott, Foresman and Company, 1914, pp. 189-190; also *Principles of Advertising,* New York: A. W. Shaw Company, 1923, pp. 668-669.

white enamel paper stock. In the one case black ink was used on the raised *letter outlines* to produce the black on white; in the other case black ink was used on the *raised background*, the letters appearing as white outlines to pro-

Black on White

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and told him he said he had never seen such dishonesty.

White on Black

6. Mr. Smith gave a newsboy a quarter for a paper and left without his change. When the boy ran and told him he said he had never seen such dishonesty.

FIG. 13. Black print versus white print.

duce the *effect* of white print on black paper. See Figure 13 for sample.

The results of the experiment are presented in Table 50. It is apparent that there is a 10.5 per cent advantage in favor of black on white.

TABLE 50

Black Print versus White Print

Note: Reading speed for white on black is compared with reading speed for material printed black on white as the standard. Ten point type, Scotch Roman, 19 pica line width, set solid was used in both arrangements. Minus (−) difference indicates slower reading than the standard. Number of readers = 280 college students.

Printing Arrangement	Differences in Per Cent
Black on White versus Black on White	0.0
Black on White versus White on Black	−10.5

It will be noted that the present experiment agrees with Starch's experiment in proving that black on white is more legible than white on black or white on gray. The greater difference found by Starch (42 per cent as against 10.5 per cent) is probably due to the fact that he compared black on white versus white on dark gray, whereas we compared black on white versus white on black.

The advertiser who contemplates utilizing white on black must decide whether or not the greater attention value of white on black through novelty will be sufficient to offset the disadvantage of a 10.5 per cent loss in reading speed. Perhaps the best compromise would be to adopt the rule that whenever white on black is employed as a device for attracting attention, the amount of reading material should be reduced to a minimum so that the question of speed of reading the advertising text ceases to be a problem of any importance.

Reader opinion is definitely in favor of black on white as is shown in Table 51. The surprising thing about these

TABLE 51

Black on White versus White on Black Ranked According to 224 Reader Opinions of Relative Legibility

Kind of Print	Percentage Ranked First
Black on White	77.7
White on Black	22.3

results is not that the majority of readers (77.7 per cent) favors black on white but that 22.3 per cent of our readers actually believe that white on black would be read faster than black on white. It is probable that some printers and

advertising experts might belong to this minority group and hence would erroneously favor white on black as being more legible. The important thing is to remember that the majority of readers agrees with the experimental results showing that black on white is far more legible than white on black.

2. Perceptibility at a Distance

Opinions expressed in the literature concerning the relative legibility of black on white and white on black are based chiefly upon studies of the perceptibility of isolated letters and words, at a distance. For example Scott,[2] using a short exposure technique, discovered that black letters on a white background were seen more frequently than white on black. His results really deal with the question of attention value of materials seen at a distance. Hollingworth,[3] in discussing Scott's results, states: "So far as acuity and legibility go there is no difference between the two arrangements." Kirschmann,[4] measuring perceptibility of block letters and geometrical forms printed black on white and white on black, reported an advantage in favor of white on black. Slefrig,[5] like Kirschmann, appears to believe that white on black is better than black on white since he states: "White letters on a dark page would be in many ways more legible than the converse."

If one were to be guided by these opinions then white on

[2] W. D. Scott, *The Theory of Advertising,* Boston: Small, Maynard and Company, 1903, pp. 138-139.

[3] H. L. Hollingworth, *Advertising and Selling,* New York: D. Appleton and Company, 1920, pp. 76-78.

[4] A. Kirschmann, "Über die erkennbarkeit geometrischer Figuren und Schriftzeichen im indireckten Sehen." *Arch. f. d. ges. Psychol.,* 1908, 13, 352-388.

[5] S. Slefrig, *The Normal School Hygiene,* London: The Normal Press Ltd., 1905, Chapter XVII.

black should be used far more frequently than it is in printing that is to be read at a distance or at a glance. Since these types of reading situations are important in advertising and merchandising (billboards, posters, car cards, window display signs, road and traffic signs, instrument dials, keyboard labels, photostats, blueprints, street signs, house numbers, etc.) it is highly desirable to determine experimentally the relative perceptibility of these two kinds of printing.

Dr. Grace Holmes[6] measured the perceptibility at a distance of words cut out of our test materials, black on white as well as white on black. On the average, words printed black on white could be seen 20.5 centimeters farther away than white on black. This represents an advantage of 14.7 per cent for black print over white print. This advantage was found to hold true for each and every one of the twenty persons tested.

Dr. Cornelia Taylor[7] conducted an even more elaborate study of this problem. She used the following methods: span of visual apprehension, perceptibility in peripheral vision, eye-movement photographs, and distance perceptibility. Every method employed by Dr. Taylor in her extensive investigation yielded results uniformly in support of the general conclusion that black print on a white background is more readily perceived than white on black. For ordinary kinds of type faces (with serifs) the results were consistent regardless of size of type. The only exception in the entire investigation was the finding that Kabel Light (an ultra-modern serifless style of type) was perceived as readily when printed black on white as when printed white

[6] G. Holmes, "The Relative Legibility of Black Print and White Print." *J. Appl. Psychol.*, 1931, 15, 248-251.

[7] C. D. Taylor, "The Relative Legibility of Black and White Print." *J. Educ. Psychol.*, 1934, 25, 561-578.

on black except in very small type size when black on white was more easily perceived.

3. Summary and Recommendations

1. Black on white is much more legible than white on black for materials to be read in the ordinary reading situation as well as for material to be read at a distance.

2. Advertisers who desire to utilize the higher attention value of white on black, which is due to novelty, should keep the amount of text material in the main body of the advertisement at a minimum. Otherwise the 10.5 per cent loss in reading speed will offset the advantage of white on black as an attention-getting device.

3. Advertisers should avoid the use of white on black in all advertising copy to be read at a distance since its legibility is quite poor.

4. Manufacturers of instrument dials, keyboard labels and signs of various kinds should avoid the use of white on black because of its poor legibility.

Chapter 10

Color of Print and Background

THE increased use of color in magazine advertising, posters, car cards, booklets, and circulars, especially during the past ten or fifteen years, emphasizes the importance of scientific knowledge concerning the effect of various color combinations of type and background on speed of reading. Colored print which is legible on one background may prove to be illegible when combined with certain other colored backgrounds.

Texts dealing with the psychology of advertising usually devote a large amount of space to the topic of color. Most of them treat attention value, color preference, and appropriateness of color combinations for particular purposes, but mention legibility only briefly. Presumably neglect of the legibility factor was due to the absence of experimental data. The only results cited were those briefly reported by Luckiesh for printed matter read from a distance.[1]

[1] M. Luckiesh, *Light and Color in Advertising and Merchandising,* New York: H. Van Nostrand Company, 1923, pp. 246-251. In this discussion he lists thirteen combinations of colored print and background in order from most legible to least legible. Detailed statements regarding the conditions of the experiment such as number of subjects, kind of ink and paper employed, size of type, line width, text used, etc., are omitted. Furthermore, the rank order, as given, affords no indication of the amount of the differences in legibility between the several combinations.

1. Color Combinations in Normal Reading Situation

Although a large number of color combinations might have been utilized in an experiment of this kind, it was necessary to limit our study to a small number of combinations.[2] The four most legible and the three least legible combinations were selected from the list reported by Luckiesh. Inspection of available colored paper stocks led to the choice of three additional color combinations. Since black on white was used as a standard, data for a total of eleven color combinations are available.

Form A was printed with black ink on white Rainbow cover stock and served as the standard in each comparison. Form B was printed with Ruxton's colored ink on Rainbow cover stock in the variations shown in Table 52.

Table 52

Color Combinations of Ink and Paper and Observed Color Eflects

Column 1 shows trade names for Ruxton's ink and Rainbow cover stock used and column 2, the observed effects of colored ink and paper combinations.

Trade Name (1)	Observed Effect (2)
Black jobbing on white	Black on light grayish white
Grass green on white	Dark green on light grayish white
Lustre blue on white	Dark blue on light grayish white
Black jobbing on yellow	Black on yellow (slight orange tinge)
Tulip red on yellow	Light red on yellow (slight orange tinge)
Tulip red on white	Light red on light grayish white
Grass green on red	Dark grayish green on red (dark tint)
Chromium orange on black	Dark lemon yellow on dark grayish black
Chromium orange on white	Light orange on light grayish white
Tulip red on green	Dark brown on dark green
Black jobbing on purple	Black on dark purple (violet)

[2] M. A. Tinker and D. G. Paterson, "Variations in Color of Print and Background." *J. Appl. Psychol.*, 1931, 15, 471-479.

The black on white is really black on light grayish-white cover stock. As nearly as we could tell by comparing, under daylight illumination, the various test blanks with the Milton Bradley Company's Studio Book of Colored Papers (8165:11-1-25), the colors of the various cover stocks approach maximum saturation (chroma). In column 2 of Table 52 an attempt has been made to indicate brightness (value) as well as hue (color) in describing the observed effects.

Results for the ten test groups, arranged in order from the color combination showing the least difference from black on white to the one showing the greatest difference, are shown in Table 53.

TABLE 53

Combinations of Colored Print and Colored Paper

Note: Reading speed for various combinations of colored print and colored paper is compared with reading speed for material printed black on white as a standard. All test blanks were printed in Scotch Roman, 10 point type, 19 pica line width set solid. Minus (–) differences indicate slower reading than the standard. Number of readers = 850 college students.

Color Combination	Differences in Per Cent
Black on White	0.0
Green on White	–3.0
Blue on White	–3.4
Black on Yellow	–3.8
Red on Yellow	–4.8
Red on White	–8.9
Green on Red	–10.6
Orange on Black	–13.5
Orange on White	–20.9
Red on Green	–39.5
Black on Purple	–51.5

In every comparison black on white yields the fastest reading time. The retarding effects of the first three color combinations are slight ranging from 3.0 to 3.8 per cent. From a practical viewpoint one might say that green on white, blue on white, and black on yellow are almost as effective as black on white in producing optimal reading conditions. The retarding effects of the remaining color combinations become more pronounced. Red on yellow shows a 4.8 per cent differential, which is sufficient to suggest the disadvantage of such a color combination whenever reading speed is a factor to be considered. In the remaining groups, the various color combinations produce very illegible text. The last four color combinations produce such unfavorable reading conditions that it is inadvisable ever to use them.

The black on purple combination was originally selected to obtain a quantitative measure of the difference when readers are confronted with an extremely illegible color combination. As a matter of fact practically all of the students exhibited varying degrees of consternation when they turned over this test blank and attempted to read it as quickly and accurately as possible.

The results we have obtained become understandable when we realize that legibility depends not upon color of print and of paper surface primarily but rather on the *brightness contrast* between print and background. This principle is so important that we are justified in calling it "the law of brightness contrast."

The four color combinations we found to have little or no adverse effect upon speed of reading are those which have a maximum brightness contrast. The five color combinations which decrease speed of reading most have a minimum brightness contrast. The remaining two color

combinations which decreased speed of reading 4.8 and 8.9 per cent have medium brightness contrast.

Persons unfamiliar with color values seldom realize that brightness contrast and color contrast are two totally different things. For example, red and green are contrasting colors, but there is little brightness contrast between them because both of them are relatively dark. Just the reverse is true with respect to orange and white. These two colors represent a real contrast in color but again there was little brightness contrast because both of them are relatively light. In other words two shades or two tints will be unsatisfactory. What is needed is a shade in combination with a tint such as is found with black on yellow. The safest rule to follow is to use a dark ink on a light background.

How misleading color combinations may be, judged solely from knowledge of color values singly, is shown by the effects disclosed by this study. For example, what the printer designates as orange on black produces the appearance of dark lemon-yellow on dark grayish-black. This same ink, when applied to white background, appears as light orange. Similar instances may be noted by referring to Table 52.

Results obtained in the present study hold only for colored inks printed on colored backgrounds. Printing processes in which both letters and background are printed with different colored ink on white paper stock so as not to overlap would produce different effects. For example, orange letters printed on white paper with a black background printed on the same white paper (two color printing) would undoubtedly present a marked brightness contrast, the orange colored ink appearing as orange rather than as lemon-yellow.

As in studies of other typographical factors we secured

the opinions of 210 college students in regard to the relative legibility of the 11 color combinations. The results are shown in Table 54. It is clear that readers tend to rank

TABLE 54

Combinations of Colored Print and Colored Paper Ranked According to 210 Reader Opinions of Relative Legibility

Color Combination	Average Rank	Rank Order
Black on White	2.1	1
Blue on White	2.8	2
Black on Yellow	2.9	3
Green on White	4.2	4
Red on Yellow	5.3	5
Red on White	5.4	6
Green on Red	5.7	7
Orange on Black	7.6	8
Orange on White	9.1	9
Black on Purple	10.2	10
Red on Green	10.5	11

the 11 color combinations in an order closely approximating the ranking produced by our performance reading tests. There are minor discrepancies, to be sure, but they are relatively unimportant. It would seem, therefore, that our student readers were guided in their judgment of relative legibility by the amount of *brightness contrast* and were not distracted by preconceived notions in regard to such things as color preferences and color contrasts.

From a practical point of view the printer who strives to produce a legible color combination through obtaining a maximum brightness contrast will not only produce a legible piece of text but will also produce a printing arrangement that will meet the approval of readers. To obtain this effect the printer must disregard color as such and

center his attention on the brightness values of the printed effect in contrast with the background.

2. Black Print on Tinted Surfaces

Stanton and Burtt,[3] using our reading performance test method, compared speed of reading black print on white paper and on ivory tinted paper. Their results clearly indicate that text printed on these two backgrounds are equally legible.

A study of the readability of black print on white and tinted papers has recently been published by Luckiesh and Moss.[4] They measured the speed at which their 20 readers *normally* or *naturally* read the textual materials. Since no control was exercised over reading attitude (what is one's normal rate of reading and how constant is it?) or comprehension, it is surprising to note that the authors expressed surprise at finding what they regarded as only small differences. They found: (1) black on a saturated yellowish-red background was read 5.6 per cent more slowly than black on white; (2) black on a fairly saturated yellow was read 6.4 per cent more slowly; and (3) black on very light buff retarded "normal" rate of reading 3.8 per cent. In general, Luckiesh and Moss concluded that black on white is more legible than black on tinted backgrounds.

3. Color Combinations in Reading at a Distance and at a Glance

The advertiser is also interested in the attention value and the legibility of different color combinations when

[3] F. N. Stanton and H. E. Burtt, "The Influence of Surface and Tint of Paper on Speed of Reading." *J. Appl. Psychol.*, 1935, 19, 683-693.

[4] M. Luckiesh and F. K. Moss, "Visibility and Readability of Print on White and Tinted Papers." *Sight-Saving Review*, 1938, 8, 123-134.

used in posters, car cards, and billboard displays. Here the problem is concerned with the distance at which isolated words can be read accurately or how accurately they can be read at a glance. It is entirely possible that a color combination might be effective in the ordinary reading situation but ineffective when read at a distance or read at a glance, and vice versa.

A special study[5] of the perceptibility of isolated words in the color combinations described above was undertaken in our laboratory. Perceptibility was measured in terms of the distance at which a word could be read accurately. The results of this study, shown in Table 55, are brought into line with performance test results reported earlier in this chapter. At first glance there are discrepancies but in general the two rank orders are similar. From the standpoint

TABLE 55

Ranking of Color Combinations According to a Reading Performance Test of Legibility and According to Perceptibility at a Distance

Color Combination	Reading Performance Legibility Rank Order	Perceptibility Rank Order
Black on White	1	4
Green on White	2	3
Blue on White	3	1
Black on Yellow	4	2
Red on Yellow	5	6
Red on White	6	7
Green on Red	7	5
Orange on Black	8	8
Orange on White	9	10
Red on Green	10	11
Black on Purple	11	9

[5] K. Preston, H. P. Schwankl and M. A. Tinker, "The Effect of Variations in Color of Print and Background on Legibility." *J. of Gen. Psychol.*, 1932, 6, 445-461.

of perceptibility or legibility at a distance the detailed results indicate that blue on white, black on yellow, green on white and black on white provide good legibility; green on red, and red on yellow provide fair legibility; and red on white, orange on black, black on purple, orange on white and red on green provide poor legibility. In other words, under both types of reading situations the law of *brightness contrast* holds.

The only other prior study of the legibility of color combinations that we have been able to locate is one conducted by Luckiesh cited at the beginning of this chapter. He used eight color combinations similar to eight of the color combinations used in our studies. Generally speaking, he obtained similar results in which brightness contrast seemed to be the all-important factor in producing perceptibility differences.

Three additional studies have appeared on this subject. Miyake, Dunlap, and Cureton, using the short exposure technique (reading at a glance), found that legibility varies directly with the brightness contrast between color of print and background.[6] Luckiesh and Moss investigated the relative visibility of black print on ten colored backgrounds, nine of which varied only slightly from pure white whereas the tenth was quite dark.[7] Except for the dark background, the differences found were slight. Sumner, using the distance method, studied the legibility of 42 combinations of colored print and colored backgrounds.[8] He confirms the law of brightness contrast discussed above.

[6] M. F. Miyake, J. W. Dunlap, and E. E. Cureton, "The Comparative Legibility of Black and Colored Numbers on Colored and Black Backgrounds." *J. Gen. Psychol.*, 1930, 3, 340-343.

[7] *Op. Cit.*

[8] F. C. Sumner, "Influence of Color on Legibility of Copy." *J. Appl. Psychol.*, 1932, 16, 201-204.

4. Color Preferences and Legibility of Color Combinations

A study of color preferences was included in Sumner's investigation of legibility mentioned above.[9] He had his subjects rank the 42 color combinations for pleasingness. Then the pleasingness rank order was compared with the legibility rank order. The two were found to be definitely related. This means that the most legible color combinations were also most preferred. Thus, both color preferences and legibility obey the law of brightness contrast.

5. Summary and Recommendations

1. Striking differences in rate of reading material printed with various combinations of colored ink and paper were found. As a rough guide for printing practice the following list is suggested:

Providing good legibility: black jobbing on white, grass green on white, lustre blue on white and black jobbing on yellow.

Providing fair legibility: tulip red on yellow and tulip red on white.

Providing poor legibility: grass green on red, chromium orange on black, chromium orange on white, tulip red on green and black jobbing on purple.

2. The opinions of readers in regard to the relative legibility of these color combinations correspond closely to the guide for printing practice outlined above. Thus printers who follow the suggested guide will prepare text material which will promote rapid reading and at the same time will meet with the approval of the reader.

[9] *Op. Cit.*

3. When black print is used with tinted backgrounds only a slight reduction in legibility occurs whereas black print on dark backgrounds produces very illegible text. This finding suggests that the printer who desires to use black ink on different colored paper stocks should restrict his choice to light tints.

4. Striking differences in the perceptibility of material printed in various combinations of colored ink and paper were also found. In general, color combinations which are legible in the normal reading situation are also found to be satisfactory for material to be read at a distance or at a glance. The following list is recommended as a rough guide in the printing of car cards, posters, billboards and other advertising material to be read at a distance:

Providing good perceptibility: lustre blue on white, black jobbing on yellow, grass green on white, and black jobbing on white.

Providing fair perceptibility: grass green on red, and tulip red on yellow.

Providing poor perceptibility: tulip red on white, chromium orange on black, black jobbing on purple, chromium orange on white, and tulip red on green.

5. Color combinations which are most legible are also those most preferred on the basis of pleasingness. Therefore, both legibility and preference obey the law of brightness contrast.

6. The above findings and recommendations hold for colored ink on colored paper stock and do not hold for two color printing (when both print and background are printed on a white background). In both kinds of printing, however, the following rule should be adhered to: In combining colors (print and background) care must be taken to produce a *printing arrangement* which shows a maxi-

mum *brightness contrast* between print and background. In other words, the printer should disregard color as such and should concentrate his attention on *brightness contrast*. This is to say that two shades or two tints in print and background should be avoided. A dark color should be used for the print and a light color should be employed for the background. The safest rule to follow is to use a dark ink on a light background.

Chapter 11

Printing Surfaces

EVERY writer on typography who has discussed the question of paper surface in printing has assumed that glossy paper should be avoided. It is pointed out that glare is optically deleterious. Although direct statements in regard to legibility are seldom made, the writers presumably believe that printing on glazed paper produces poor legibility. Pyke,[1] however, in reviewing this literature admits that it is still an open question.

The following opinions may be taken as representative. W. Morris claims that the paper surface should be hard, little ribbed, durable and unglazed. E. B. Huey asserts that the paper should be "without gloss." The Committee of the American School Hygiene Association recommended "the paper should be unglazed, free from shine, and opaque." The British Association Committee states that the paper should have no glaze and that glare is likely to be injurious when specular reflection (like from a mirror) exceeds 56 per cent. The Committee of Illuminating Engineers' Society held that from the reader's point of view print paper should possess little gloss. The Committee stated, "any glazing is entirely deleterious optically." J. Kerr's statement in 1925 may be taken as a summary of the views of previous writers when he says, "For the avoidance of glare the paper must be without gloss, so hard as to take a clean impression and not to be easily dirtied."

[1] *Op. cit.*

It is significant that none of the above opinions are based upon experimental tests. In fact only one experimental investigation of this specific subject has been reported in the scientific literature. This is the oft quoted classical experiment of Roethlein. She compared the perceptibility of type faces printed on "white coated book paper" and "very slightly yellowish antique laid book paper." She found a maximum legibility difference between the two of only 3 per cent. Furthermore, no constancy of preference among individuals for either paper surface was found. She concluded "the quality and the texture of the paper is a much less significant factor than has been supposed—provided, of course, that the illumination and the inclination of the paper are such as to secure an optimal condition of light reflection from its surface." A similar investigation was made in our laboratory using the distance method.[2] No difference was found between eggshell paper stock and Artisan enamel paper stock, and only a slight difference (1.6 per cent) between eggshell and Flint enamel paper stock.

As we have pointed out in an earlier chapter, the distance method cannot be accepted as valid for questions concerning legibility of type in ordinary reading situations. However the above findings may be accepted as significant for printing which is to be read at a distance such as car cards, window posters and billboards.

1. Our First Study

In April, 1932 we completed a study on the influence of paper surface (dull finish vs. glossy finish) on speed of reading. The results are shown in Table 56. It is apparent that college students read material printed on glossy paper as rapidly as, if not more rapidly than, material printed on

[2] H. A. Webster and M. A. Tinker, "The Influence of Paper Surface on the Perceptibility of Print." *J. Appl. Psychol.*, 1935, 19, 145-147.

Table 56

Eggshell versus White Enamel

Note: Reading speed for white enamel paper stock is compared with reading speed for eggshell paper stock as the standard. Plus (+) difference indicates faster reading than the standard. Number of readers = 190 college students.

Paper Stock	Differences in Per Cent
Eggshell vs. Eggshell	0.0
Eggshell vs. White Enamel	+1.6

a dull surface. Strictly speaking, there is a slight though unimportant advantage in favor of the glossy paper.

2. Our Second Study

When we had completed this first study and made a preliminary report[3] we learned that Stanton and Burtt had completed a similar study at Ohio State University with results apparently showing marked differences among the paper surfaces used. No control group was utilized in their study, however, and it is possible that the differences found were due to constant errors. At a later date, Stanton and Burtt repeated the experiment with a control group and when the constant errors were corrected no differences appeared.[4] In the meantime, we undertook a second experiment as a check on our first study. This study, employing three degrees of gloss, was completed in May, 1933. Our typographical set-up remained the same and eggshell paper was again utilized as a standard. The two glossy paper

[3] M. A. Tinker, "Studies in Scientific Typography." *Psychol. Bull.*, 1932, 29, 670-671.

[4] F. N. Stanton and H. E. Burtt, "Influence of Surface and Tint of Paper on the Speed of Reading." *J. Appl. Psychol.*, 1935, 19, 683-693.

surfaces employed for the experimental variables were Artisan enamel and Flint enamel. The standard paper surface and the two enamel surfaces were measured at the United States National Bureau of Standards by means of the Glarimeter. The report from the Bureau of Standards gives the following percentages of glare: eggshell = 22.9%; Artisan enamel = 85.8%; Flint enamel = 95.1%.

The results of our second study are shown in Table 57. Again it is apparent that all three paper surfaces produce printing material that is equally legible. There is a suggestion that material printed on Flint enamel is read at a slightly slower rate. The difference, however, is not statistically significant and is of no practical importance.

TABLE 57

Eggshell vs. Artisan Enamel and Flint Enamel

Note: Reading speeds for Artisan Enamel (85.8% glare) and for Flint Enamel (95.1% glare) are compared with reading speed for eggshell paper stock (22.9% glare) as a standard. Minus (–) differences indicate slower reading than the standard. Number of readers = 255 college students.

Paper Stock	Differences in Per Cent
Eggshell vs. Eggshell	0.0
Eggshell vs. Artisan Enamel	+0.4
Eggshell vs. Flint Enamel	–2.9

In three additional studies, to be reported in the next chapter, we also found that paper surface was of little or no importance in its effects on legibility.

The facts found in all six studies contradict common sense notions and opinions that have been current. It is possible, of course, that a glossy printing surface in itself tends to retard reading more than dull finish paper stock.

There may be an advantage, however, inhering in glossy paper stock printing that offsets its disadvantages. We refer to the fact that greater brightness contrast is usually present because the glossy paper approaches "pure white" whereas eggshell paper stock is usually somewhat tinged with yellow or gray. Furthermore, a sharper printing impression is made on the harder surface afforded by glossy stock. A consideration of all of these factors suggests why our findings fail to show any difference between glossy and dull finish paper stock.

The reader is cautioned to accept the findings as being true only for relatively short periods of reading. It is possible that relatively long periods of reading print on glossy paper will result in eyestrain and fatigue. Although our results and those reported by Stanton and Burtt throw no light on this problem, nevertheless, the results justify the practice of printing a few pages in a book on glossy paper in order to accommodate half-tone illustrations. It is also obvious that the printing of advertising circulars on glossy paper can be done safely without any loss of legibility. Perhaps when more ideal conditions of illumination prevail, even the printing of books and magazines on glossy paper will be justified so far as speed of reading is concerned. This assumes that uniform distribution of light can be achieved so that glare effects are eliminated or greatly reduced.

3. Reader Opinions

Since our reading test technique shows no important differences, it becomes desirable to determine whether readers are equally indifferent toward the use of glazed paper surfaces. We, therefore, secured opinions of relative legibility from 224 readers. The results, shown in Table

TABLE 58

Printing Surfaces Ranked According to 224 Reader Opinions of Relative Legibility

Paper Surface	Average Rank	Percentage of Votes for First Place
Eggshell	1.3	75
Artisan Enamel	1.9	19
Flint Enamel	2.8	6

58, indicate that there is a definite consensus to the effect that material printed on eggshell paper stock is much more legible than material printed on glazed paper. Thus, readers prefer dull finished paper stock and printers should be guided accordingly.

It is probable that reader opinion is antagonistic to glazed paper printing because of the frequency with which reading must be carried on under unsatisfactory conditions of illumination. Direct lighting continues to characterize most reading situations. Perhaps, when illumination systems yield a high degree of diffused light, we will find that reader prejudices against glazed paper printing will tend to disappear. Until that day arrives, however, the printing industry will wisely restrict printing on glazed paper to a minimum.

4. Summary and Recommendations

1. Actual reading tests show that there is no difference in legibility between material printed on highly glazed paper and material printed on dull finish paper stock. These results indicate that car cards, window posters, and circulars can be printed on glazed paper without reducing legibility. The results also indicate that printed material

can appear on a few pages of glazed paper here and there in a book or magazine in order to accommodate half-tone illustrations without loss of legibility.

2. In spite of the facts obtained from actual tests, the printer should, whenever possible, use dull finish paper stock in order to meet the opinions and prejudices of the overwhelming majority of readers who believe that they can read material printed on dull finished paper more rapidly than material on glazed paper. It is good business to give the readers what they want whenever reader preferences can be followed without loss of legibility.

Chapter 12

Optimal Versus Non-Optimal Printing Arrangements

FOR the most part, preceding chapters have aimed to set forth optimal printing arrangements so far as one, two, or three typographical factors are concerned. In this chapter we have approached the problem from a totally different point of view. We have started with an optimal printing arrangement with respect to type size, line width, leading, color of print and background and paper surface. Then we have varied each of these factors singly and in combination to discover whether or not the combination of more than one non-optimal factor would produce a cumulative adverse effect on speed of reading. In this way we hoped to verify findings we discovered in our previous experiments. Thus, we would have impressive additional evidence in regard to the accuracy of our main studies and at the same time could demonstrate the dangers of incorporating two or more non-optimal conditions in a given printing arrangement.

In setting up our test materials for this study we have not attempted to produce impossible printing arrangements. Rather we have kept within reasonable limits so far as printing practice is concerned. In this way our findings cannot be regarded as merely bizarre combinations divorced from conceivable printing practice.

From a theoretical point of view it is highly important

to know whether or not a number of typographical factors, each affecting speed of reading, singly, will operate with increasing effects when combined. Theoretically, the problem is more than knowing whether or not two or more factors will act conjointly. We really want to know if a combination of factors acts cumulatively, or synergistically. In other words, will two factors, each retarding speed of reading by 5 per cent, produce when combined a 10 per cent retardation which would be a cumulative effect? Or will the combined effect produce a 15 or 20 per cent retardation which would be synergistic effect? Or will the combined effect be non-additive in which case the retardation effect would remain approximately at the 5 per cent level? Still another possibility exists, namely, that two non-optimal arrangements will be worse than either one alone, but the combined effect will not be twice as bad and thus will not be strictly cumulative.

In attacking this problem we have completed three studies. The first deals with 10 point type, the second compares 8 point with 10 point type, and the third compares 6 point with 10 point type.

1. Study I. Ten Point Type

The results for the variations in our study of 10 point type are contained in Table 59. As indicated in the table we have arranged the variations in an order going from the standard as an optimum to increased changes in leading, print and background, paper stock and type face. In Test Group II the only change is an increase in line width from 19 picas in the standard to 44 picas. This change retards speed of reading 7.5 per cent. In Test Group III we have introduced a change in leading as well as in line width and the retarding effect is 10.1 per cent. In Test

Study I. Optimal Versus Non-Optimal Printing
Arrangements for Ten Point Type

Note: Reading speeds for 44 pica line widths leaded two points or set solid, set in Scotch Roman or Cloister Black, printed black on white or white on black, and on enamel paper stock or eggshell paper stock are compared with reading speed for Scotch Roman printed in 19 pica line width leaded: points printed black on white enamel paper stock as a standard. Minus (–) differences indicate slower reading than the standard. Number of readers = 744 college students.

Test Group	Typographical Arrangement of Form B: Size of Type in Points	Line Width in Picas	Leading in Points	Type Face	Print and Background	Paper Stock	Difference from Standard in Per Cent
I*	10	19	2	Scotch Roman	Bl. on Wh.	Enamel	0.0
II	10	44	2	" "	" " "	"	–7.5
III	10	44	0	" "	" " "	"	–10.1
IV	10	44	0	" "	" " "	Eggshell	–8.2
V	10	44	2	" "	Wh. on Bl.	Enamel	–14.5
VI	10	44	0	" "	" " "	"	–18.4
VII	10	44	0	" "	" " "	Eggshell	–18.7
VIII	[illegible]	[illegible]	[illegible]	Cloister Bl.	Bl. on Wh.	Enamel	[illegible]

Group IV the same long line set solid is used but this time eggshell paper stock is employed and the retarding effect is 8.2 per cent. We should be inclined to interpret the results for Test Groups II, III, and IV as meaning that these three variations produce approximately the same amount of retardation in speed of reading. In other words, with such a long line width leading has only a slight beneficial effect and kind of paper surface used is immaterial. This finding is in harmony with and thus strengthens our previous finding that leading is not very important for long line widths.

When we observe the effect of printing white on black (Test Group V) we note that the retarding effect is 14.5 per cent. The size of this effect is greater than that found in our previous study of white on black printing and may be attributed to the combined effect of a long line width coupled with white on black printing.

The next two test groups (VI and VII) continue the white on black printing arrangement but the text is set solid and in Group VII the paper stock shifts from enamel to eggshell. The net result is a retarding effect of about 18.5 per cent in both cases. Thus lack of leading produced a slight retardation but change in paper stock is again immaterial.

The final comparison, in which Cloister Black is introduced, shows a retardation of 22.3 per cent. In other words, a long line width, set solid and printed with Cloister Black type is a very bad combination indeed. We can assume that a still worse arrangement would have been a long line width, set solid, using Cloister Black type and printed white on black.

We interpret the results in Table 59 to mean that the combination of non-optimal factors produces a deleterious

10 pt., 19 picas, 2 pt. lead., Scotch R., wh. on bl., enamel

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had

10 pt., 44 picas, set solid, Scotch R., bl. on wh., wh. enamel

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

10 pt., 44 picas, set solid, Scotch R., wh. on bl., wh. enamel

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

10 pt., 44 picas, set solid, Scotch R., bl. on wh., wh. eggshell

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

10 pt., 44 picas, set solid, Scotch R., wh. on bl., wh. eggshell

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

10 pt., 44 picas, set solid, Cl. Black, bl. on wh., wh. enamel

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

10 pt., 44 picas, 2 pt. lead., Scotch R., bl. on wh., wh. enamel

1. Mary was sitting on the seashore one hot day in June. She said to her mother, "If only I had brought my skates along, I could have had great fun." 2. The house was brightly lit and a merry and happy party was going on.

Study II. Optimal Versus Non-Optimal Printing Arrangements
for Eight Point Type in Comparison with Ten Point Type

Note: Reading speeds for 8 point type, 40 pica line width, leaded 2 points or set solid, set in Scotch Roman on Cloister Black, printed black on white or white on black, and on enamel or eggshell paper stock are compared with reading speed for Scotch Roman, 10 point type printed in 19 pica line width, leaded 2 points printed black on white enamel paper stock as a standard. Minus (–) differences indicate slower reading than the standard. Number of readers = 744 college students. These student readers are different from those used in Study I with the exception of Test Group I.

Test Group	Typographical Arrangement for Form B						Difference from Standard in Per Cent
	Size of Type in Points	Line Width in Picas	Leading in Points	Type Face	Print and Background	Paper Stock	
I*	10	19	2	Scotch Roman	Bl. on Wh.	Enamel	0.0
II	8	40	2	" "	" " "	"	−9.9
III	8	40	0	" "	" " "	"	−9.9
IV	8	40	0	" "	" " "	Eggshell	−11.2
V	8	40	2	" "	Wh. on Bl.	Enamel	−19.1
VI	8	40	0	" "	" " "	"	[illegible]

effect which is additive but falls short of being strictly cumulative. Thus the combination of deleterious factors produces a progressively poorer typographical arrangement from the standpoint of speed of reading.

2. Study II. Eight Point Type

The typographical arrangements utilized in our comparison of 8 point type with 10 point as a standard are essentially the same as those used in Study I. The results shown in Table 60 are similar to those in Study I. The smaller type in the long line width retards speed of reading 9.9 per cent and leading or the absence of leading makes little or no difference. Similarly, paper stock makes little difference. Printing white on black, however, brings about a marked further decrease in speed of reading. Cloister Black, printed black on white is as bad as, if not a bit worse than white on black.

The general interpretation of the results in Table 60 is similar to the interpretation arrived at in Study I.

3. Study III. Six Point Type

Again the results show that a small type in a long line width retards speed of reading 6 per cent (Table 61). When this arrangement, which is leaded 2 points, is set solid the retarding effect is 14 per cent. This suggests that 2 point leading is important for 6 point type.

As found in Studies I and II, paper stock is relatively unimportant. White on black printing and Cloister Black are both found to be extremely unsatisfactory.

4. Summary

Our three studies designed to compare non-optimal printing arrangements with typographical arrangements

TABLE 61

Study III. Optimal Versus Non-Optimal Printing Arrangements for Six Point Type in Comparison with Ten Point Type

Note: Reading speeds for 6 point type, 34 pica line width, leaded 2 points or set solid, set in Scotch Roman or Cloister Black, printed black on white or white on black, and on enamel or eggshell paper stock are compared with reading speed for Scotch Roman, 10 point type printed in 19 pica line width, leaded 2 points, printed black on white enamel paper stock as a standard. Minus (−) differences indicate slower reading than the standard. Number of readers = 744 college students. The student readers are different from those used in Studies I and II with the exception of Test Group I.

Test Group	Typographical Arrangement for Form B						Difference from Standard in Per Cent
	Size of Type in Points	Line Width in Picas	Leading in Points	Type Face	Print and Background	Paper Stock	
I*	10	19	2	Scotch Roman	Bl. on Wh.	Enamel	0.0
II	6	34	2	" "	" " "	"	−6.0
III	6	34	0	" "	" " "	"	−14.0
IV	6	34	0	" "	" " "	Eggshell	−10.4
V	6	34	2	" "	Wh. on Bl.	Enamel	−17.3
VI	6	34	0	" "	" " "	"	−22.2
VII	6	34	0	" "	" " "	Eggshell	−23.3
VIII	6	34	0	Cloister Bl.	Bl. on Wh.	Enamel	−26.2

* Control Group

selected as optimal reveal a progressively retarding effect on speed of reading as one decreases the size of type, increases the width of line, decreases the amount of leading and changes the type face to Cloister Black or introduces white on black printing. The last two factors produce an extremely unsatisfactory printing situation. In all three studies paper surface is found to be relatively unimportant and leading is of minor importance for long line widths except for a very small type size.

On the theoretical side we have proof in these three studies that the introduction of undesirable variations in two or more typographical factors is accompanied by increased retardation in speed of reading. The combined effect of two or more such factors, however, is not strictly cumulative. In other words, these factors work together, it is true, but their combined effect cannot be predicted exactly from a knowledge of their separate effects.

The practical significance of these three studies is to be found in the fact that it is possible, on the basis of our numerous studies of specific factors, to specify an optimal printing arrangement. This is shown by the fact that in every comparison the standard optimal printing arrangement which we selected proved to be superior to every non-optimal arrangement.

Chapter 13

Summary of Recommendations

IN EACH of the preceding chapters we have interpreted our detailed studies of various typographical arrangements and have presented general and specific conclusions. Recognizing that the writer of printing specifications may wish to have these brought together in one place for ready reference, we devote our concluding chapter to a résumé of our recommendations. In so doing, we run the risk of dogmatism, since such a summary removes the particular conclusions from the description of the conditions which prevailed. This being true, we would suggest that the reader who doubts the practicality or the scientific soundness of any recommendation should consult the chapter describing the particular study.

Styles of Type Face

1. Since our studies show that type faces in common use are equally legible it follows that any modern type face such as Garamond, Antique, Scotch Roman, Bodoni, Old Style, Caslon, and Cheltenham may be used.

2. Readers prefer a modern type face that appears to border on bold face, hence there is an advantage in employing such a type face as Antique or Cheltenham.

3. American Typewriter type definitely retards speed of reading and therefore should not be used unless a novelty effect is desired.

4. Old English type (Cloister Black) seriously slows down reading speed, hence its use should be restricted to those situations where brief messages of a sacred, solemn or formal kind are appropriate.

5. Ultra modern type such as Kabel Light does not retard reading speed to any great extent, therefore such type may be freely used in advertising copy and possibly in book and magazine printing as well.

Type Form

6. Material printed in italics is read almost as fast as material printed in ordinary lower case. Readers, however, strongly prefer lower case printing, presumably because they believe that reading italics is accompanied by eyestrain. *The use of italics, therefore, should be restricted to very short passages used solely for the purpose of emphasis.*

7. Material set in all capitals is read much more slowly than material set in lower case and reader preference is decidedly in favor of lower case printing. For these two reasons it would be wise to AVOID PRINTING IN ALL CAPITALS not only in text material but also in newspaper and magazine headlines as well.

8. Bold face printing neither slows down nor speeds up reading rate. Yet readers believe that it is far more illegible than ordinary type. **For this reason bold face printing should be used sparingly and then only when emphasis is desired.**

9. Bold face printing, although found to be unsatisfactory for ordinary printing, should, nevertheless, be freely used for car cards, posters, etc., since definite evidence exists proving that bold face type is more legible than ordinary type in reading at a distance.

Size of Type

It is difficult if not impossible to determine the effect of type size on speed of reading without controlling or varying line width and leading. The problem is further complicated by the fact that there is probably an optimal line width and an optimal amount of leading for each type size. Recommendations in regard to type size, therefore, are hazardous. For this reason our recommendations in regard to type size are somewhat indefinite and tentative, and are confined to an average line width of about 19 picas (slightly over three inches) set solid.

10. Eleven point type seems to be better than larger or smaller type sizes. Readers also definitely favor 11 point type.

11. Apparently one can vary type size from 8 point to 12 point without markedly affecting speed of reading. Readers, however, prefer 10, 11, and 12 point type over 8 and 9 point type.

12. Type sizes smaller than 8 point or larger than 12 point are quite unsatisfactory.

Width of Line

Recommendations in regard to line widths must necessarily be limited to particular type sizes and amounts of leading. Our findings in general run contrary to the emphasis most writers on typography place on line width.

13. For 10 point type set solid three studies show that line widths between 17 and 28 picas are equally legible, whereas shorter or longer line widths are undesirable.

14. For 10 point type leaded 2 points the limits of "equal legibility" range from 14 to 31 picas.

15. In view of the fact that leading permits greater flexibility in line widths, double-column printing using 10 point

type and line widths as short as 14 picas, should be leaded 2 points.

16. For 12 point type set solid or leaded one or two points, line widths can be varied between 17 and 40 picas without apparent loss in legibility.

17. For 8 point type set solid, line widths can be varied between the limits of 13 and 25 picas. Longer and shorter line widths are inadvisable.

18. For 8 point type leaded 2 points, line widths varying between 14 and 36 picas are read equally fast.

19. For 6 point type set solid, line widths can also be varied between 9 picas and 25 picas without loss of legibility. Longer or shorter line widths, of course, retard speed of reading.

20. For 6 point type leaded 2 points, line widths between 9 and 28 picas are equally legible. Even a short line width of 7 picas and a long line width of 36 picas does not slow up reading speed to any marked degree.

21. Taking our studies on line widths as a whole, the evidence is clear that printers should pay more attention to the necessity for optimal amounts of leading than to the question of proper line widths. This is especially true for type sizes of 8 and 10 points.

22. Our study of reader preferences indicates quite clearly that readers believe that moderate line widths (such as 19 picas for 10 point type) are more legible than longer or shorter line widths. Printers, therefore, would do well to stick to moderate line widths even though line widths are really not a very important factor in legibility.

Size of Type in Relation to Width of Line

23. Our experiment, in which type size and line width for material set solid were varied simultaneously (line for

line printing) shows that printers can safely use 8 or 10 point type but that 12 and 14 point type will produce less legible copy and 6 point type will produce very illegible copy.

These findings taken in connection with our other studies of type size and considering reader preferences lead us to recommend that printers should tend to concentrate on 10 and 11 point type printed in moderate line widths.

Leading

Our experiments on leading deal with particular type sizes and line widths and our recommendations must be restricted to the specific situations studied. In general, leading seems to be an important factor tending to promote good legibility. However, it is safer to draw up specific rules in regard to leading that are definitely limited to particular sizes of type and line widths.

24. For 10 point type and a 19 pica line width, 2 point leading is optimal. One point leading is no better than set solid and both should be abandoned in printing practice. More than 2 point leading is not only not desirable but also is actually disadvantageous. Furthermore, readers prefer 2 point leading.

25. For 12 point type and a 25 pica line width, material set solid is read just as rapidly as when leading is introduced. Therefore, whenever 12 point type in a moderate line width is used, it is desirable to dispense with leading.

26. For 8 point type and a 17 pica line width, one point leading is far better than material set solid. Two point leading is also better than set solid but is no better than one point leading.

27. The theory that 8 point type with 2 point leading

would be read more rapidly than 10 point set solid was found to be false. Furthermore, readers prefer 10 point set solid as against 8 point leaded with 2 points. We recommend, therefore, that a larger size of type set solid should be used rather than a smaller size of type leaded.

Type Size, Line Width and Leading

In view of the fact that type size, line width, and leading work together in their effects on legibility it was necessary to study all these factors simultaneously in order to arrive at recommendations that would be of maximum general value to the printer. The net result of these special studies is to provide us with "safe limits" with respect to line width and leading for each of the commonly used type sizes. These safe limits we have labeled "safety zones" and the printer should consult Tables 34, 35, 36, 37, and 38 for detailed findings. The general results are presented below as recommendation 28.

28. Safety zones:

6 point: 14 picas set solid through 28 picas leaded one or more points and 36 picas leaded 2 or more points.
8 point: 14 picas set solid through 28 picas leaded one or more points and 36 picas leaded 2 or more points.
10 point: 14 picas, one or more points leading to a line width somewhat under 31 picas with the exception that 2 point leading should be used with a 19 pica line width.
11 point: 16 picas leaded to a 34 pica line width leaded one or 2 points.
12 point: 17 picas set solid to 33 picas leaded one or more points.

28a. Having established optimal line widths and leading

for the type sizes listed above we were able to make a final study of the relative legibility of 6, 8, 9, 10, 11, and 12 point type each leaded 2 points and printed in an appropriate line width. The results show that 9, 10, 11, and 12 point type sizes are equally legible whereas 8 point type somewhat retards speed of reading and 6 point type markedly slows up reading speed.

Spatial Arrangements of the Printed Page

29. There is such great diversity with respect to page sizes in textbooks and scientific journals that it would be highly desirable for publishers, printers and paper stock manufacturers to arrive at a standardization of page sizes so that the present waste of paper could be reduced.

30. A further great saving in the printing of books and magazines could be made if printers would dispense to a large degree with marginal space. This recommendation is based upon the fact that margins do not promote legibility.

31. The trend toward double-column printing might well be extended, not only in the composition of scientific magazines, but also in the printing of textbooks. This would also lead to greater economy in printing and would meet with reader approval.

32. We recommend that one-half pica space between columns be adopted for multiple-column printing because this arrangement is just as legible as wider spaces or the use of rules. Here again is a recommendation designed to cut down book and magazine costs.

33. The proposal that the indentation of every other line of print might increase legibility was found to be false, hence the present practice of printing all lines flush except at the beginning of each paragraph should be continued.

Color of Print and Background

34. Black print on white background is much more legible than white on black. The difference is so great that white on black should never be used except for a very brief message in an advertisement which uses white on black as a device for attracting attention.

35. White on black is so illegible in reading at a distance or at a glance that it should never be employed in car cards, billboards, etc.

36. The legibility of white on black is so poor that manufacturers of instrument dials, keyboard labels, license plates and other kinds of signs should avoid this kind of printing by sticking to black on white.

37. In using colored ink on colored paper stock, the following rule should be adhered to: in combining colors (print and background) care must be taken to produce a *printing arrangement* which shows a maximum *brightness contrast* between print and background. Just what colors are used is relatively unimportant. The important thing is to produce the maximum amount of brightness contrast possible between print and background. For example, a dark color should be used for the print and a light color should be employed for the background. In other words, two shades for both print and background or two tints in print and background should be avoided. The safest rule to follow is to use a dark ink regardless of color on a white or a light colored background. See summary and recommendations at the end of Chapter X for examples of printing inks which will provide good legibility.

Paper Surface

38. Surprisingly enough, reading tests show that there is no difference in legibility between material printed on

highly glazed paper and material printed on dull finished paper stock. It is possible, of course, that if longer reading tests were employed one would find a loss of legibility in reading material printed on glazed paper stock because of eye strain and fatigue. In the meantime it is safe to print car cards, window posters and circulars on glazed paper because legibility will not be affected. Also printed material can appear on a few pages of glazed paper in a book or magazine to accommodate half-tone illustrations without loss of legibility.

39. In spite of the fact that no differences in legibility were found for different paper surfaces, the printer should whenever possible use dull finish paper stock to meet the opinions and prejudices of the overwhelming majority of readers who believe that dull finish paper greatly promotes legibility and also to insure good legibility even under poor conditions of artificial light distribution.

40. It is obvious that the use of thin, semi-transparent paper should be avoided because of possible blur effects due to print showing through.

Optimal versus Non-Optimal Printing Arrangements

41. Three special studies designed to compare non-optimal arrangements with typographical arrangements selected as optimal indicate quite clearly that printers should avoid the use of one or more arrangements found in our numerous experiments to be disadvantageous. Small sizes of type, excessively short or excessively long line widths, absence of leading for moderate sized or small sized type, type faces such as Cloister Black or white on black printing are all found to be disadvantageous. As before, paper surface is relatively unimportant.

42. The facts disclosed by our study of optimal and non-optimal printing arrangements as well as the detailed findings set forth in the preceding chapters, lead us to recommend the following printing arrangements for textbooks or scientific magazines. In presenting our recommendations we first give a generalized tabular summary followed by detailed specifications for an "ideal" page.

In drawing up in tabular form our general recommendations we have listed optimal printing arrangements in the second column together with undesirable printing arrangements in the third column. See pages 156 and 157. Careful study of this table will show gaps in the printing arrangements covered. These gaps consist of "intermediate" printing arrangements that are only tolerably satisfactory, that is, neither very good nor very bad.

In presenting on pages 158 and 159 specifications for an "ideal" printed page, double-column printing and single-column printing, we have relied upon our findings with respect to legibility and reader preferences taken in conjunction with considerations of printing economy. It is obvious that variations from the "ideal" page could be introduced without loss of legibility providing the printer sticks closely to the general recommendations listed in the Tabular Summary. In other words, there is no single printing arrangement that would always be better than any other.

Tabular Summary of Typography Recommendations

Typographical Factors	Satisfactory Printing Arrangements	Undesirable Printing Arrangements
1. Style of type face	Any commonly used modern or ultra modern type face.	American Typewriter, Old English.
2. Type form	Caps and lower case. Bold face for emphasis and for reading at a distance. Italics for emphasis only.	All capitals.
3. Size of type	9, 10, 11, or 12 point leaded and in optimal line widths.	6 and 7 point; larger than 12 point.
4. Width of line	Moderate line widths (in neighborhood of 19 picas).	Excessively short line widths (less than 14 picas). Excessively long line widths (more than 28 picas).
5. Leading in relation to type size and line width:		
6 point type	2 point leading, 14 to 28 pica line width.	Set solid in short line widths (less than 14 picas), or in long line widths (more than 28 picas).
8 point type	2 point leading, 14 to 28 pica line width.	Set solid in short line widths (less than 14 picas) or in long line widths (28 picas or more).
10 point type	2 point leading, 14 to 28 pica line width.	Set solid and leaded one point in all line widths.
11 point type	2 point leading, 16 to 28 pica line width.	Set solid in short line widths (16 picas and shorter) and in long line widths (more than 28 picas).
12 point type	Set solid or leaded one or 2 points in moderate line widths (in neighborhood of 25 picas).	Set solid or leaded in short line widths (9 picas or less) and in long line widths (more than 33 picas).

Tabular Summary of Typography Recommendations

(*Continued*)

Typographical Factors	Satisfactory Printing Arrangements	Undesirable Arrangem
6. Margins	One-quarter inch for top, outer, and bottom margins, three-quarters inch for inner margin.	Wide margins sary from st of legibility
7. Columnar arrangement	Single column or double column.	Readers dislik column cor in compari double-colu
8. Space between columns	One-half pica space with no rule.	Inter-columna more than pica space sary on bas bility.
9. Color of print and background	Black print on white background, or dark colored print on light colored background.	White on blac print on da ground, or l on light bac
10. Paper surface	Dull finish opaque paper stock.	Glazed paper factory be poorly dis artificial li

Printing Specifications for an Ideal Printed Page Using Double-Column Composition

Style of type face: Cheltenham or Antique.
Size of type for text: 11 point.
Line width: 19 picas.
Leading: 2 points.
Paper surface: dull finish opaque paper stock.
Width of inside margin: ¾ inch.
Width of top, outside and bottom margins: ¼ to ¾ inch.
Columnar arrangement: double-column composition.
Inter-columnar space: ½ pica (no rule).
Total page size: 7⅜ x 9½ inches.
Running heads: caps and lower case.
Section headings: caps and lower case.
Paragraph headings (if used): caps and lower case in bold face.
Color of ink: jobbing black.
Color of paper: white.
Footnotes: 8 point, leaded one point, 19 pica line width.
Page numbers: Cheltenham or Antique, 11 point.
Chapter numbers: Cheltenham or Antique Arabic, 14 point, bold face.
Chapter headings: Cheltenham or Antique, 14 point, bold face, caps and lower case centered on page.
Specifications for tables: Cheltenham or Antique type face, Arabic numerals, 9 point lower case type for headings and numerals, rules in headings but not between columns of data, caps and lower case bold face for table titles, 9 point with 2 point leading in lower case for notes below titles.

Printing Specifications for an Ideal Printed Page Using Single-Column Composition

Style of type face: Cheltenham or Antique.
Size of type for text: 11 point.*
Line width: 22 picas.*
Leading: 2 points.
Paper stock: dull finish, opaque paper stock.
Width of inside margin: ¾ inch.
Width of top, outside and bottom margins: ¼ to ¾ inch.
Columnar arrangement: single-column composition.
Total page size: 4⅝ x 7 inches.*
Running heads: caps and lower case.
Section headings: caps and lower case.
Paragraph headings (if used): caps and lower case in bold face.
Color of ink: jobbing black.
Color of paper: white.
Footnotes: 8 point, leaded one point, 22 pica line width.*
Page numbers: Cheltenham or Antique, 11 point.*
Chapter numbers: Cheltenham or Antique Arabic, 14 point, bold face.*
Chapter headings: Cheltenham or Antique, 14 point, bold face, caps and lower case centered on page.*
Specifications for tables: Cheltenham or Antique type face, Arabic numerals, 9 point lower case type for headings and numerals, rules in headings but not between columns of data, caps and lower case bold face for table titles, 9 point with 2 point leading in lower case for notes below titles.*

* The above specifications are for books of short or moderate length. Since the results cited earlier show that considerable variation in type size and line width is possible without loss of legibility, these items would probably be changed in longer books.

Appendix I

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Methodology

A GENERAL account of the methods employed in our experimental studies has been presented in Chapter I. While that account may suffice for the general reader, nevertheless, the research worker and the student of typography will desire complete information regarding details of the method. The significance of our findings hinges directly upon the validity of every phase of our established procedures.

Reading Performance Technique

When we undertook our studies in 1927, progress in the field of standardized achievement tests had reached the point where a simple reading test admirably suited to our special purpose was available. J. C. Chapman and S. Cook had developed a speed of reading test based on the principle of measuring one and only one variable at a time.[1] In constructing their test, care was taken to make the vocabulary so simple that even fourth grade elementary school children

[1] J. C. Chapman and S. Cook, "The Principle of the Single Variable in a Speed of Reading Cross-Out Test." *J. of Educ. Res.*, 1923, 8, 389-396.

would be familiar with almost all the words. We have subjected this claim to analysis by means of Thorndike's classification of the twenty thousand most frequently used words in a running count of ten million words.[2] This analysis revealed that approximately 80 per cent of the words in the Chapman-Cook tests are found among the 500 most frequently printed words in the English language. About 88 per cent are found among the first thousand, and 95 per cent are found among the first three thousand. Only rarely was a word found with a frequency placing it beyond the first five thousand. Thus for adults and even for children it is clear that the vocabulary content is extremely simple.

Care was taken also to avoid unusual construction forms and the ideas contained in the paragraphs were kept well within the daily experience of everyone. Success in reducing the comprehension factor to a minimum is shown by the Chapman-Cook analysis of the accuracy with which elementary school children were able to read the paragraphs even when the reading was done under a "set" for speed. The average percentage of accuracy obtained by Chapman and Cook for several hundred sixth and seventh grade pupils was 94.5. Webster, in an unpublished study at Minnesota, later tested 600 fourth and fifth grade children and obtained a 96.0 average percentage of accuracy. In our own tests of college students the average percentage of accuracy was 99.7. All of this evidence substantiates the claims made by Chapman and Cook. Thus, the Chapman-Cook Speed of Reading Tests, even when read under instructions "to read as fast as possible without making mistakes," yield a direct measure of speed as a single variable little complicated by the comprehension factor.

An additional virtue of the test is to be found in the fact that each paragraph is equal to every other paragraph in

[2] E. L. Thorndike, *A Teacher's Word Book,* New York: Teachers College, Columbia University Bureau of Publications, 1931, pp. vii + 182.

length (30 words each) and also in time required for reading. In all, there are 60 paragraphs, 30 in Form A and 30 in Form B. Since the two forms are presumably equal in difficulty it is a simple matter to study the influence of any particular typographical factor on speed of reading. By printing Form A in one arrangement and Form B in a different arrangement and then having each of a group of persons read Form A and Form B it is possible to compare the relative efficiency of the two typographical set-ups. The validity of all such comparative measures of typographical efficiency is dependent upon the equivalence of difficulty in Forms A and B. Unfortunately, Chapman and Cook failed to publish proof of such equivalence so it was necessary for us to check carefully on this vital question.

Equivalence of Forms A and B

Data from a variety of sources are available to show that the two forms are equivalent but the equivalence holds only under certain conditions, namely when and only when Form

Table I

Equivalence of Difficulty of Forms A and B of the Chapman-Cook Speed of Reading Test

Note: Form B followed Form A and both forms were typographically identical.

Test Group	Number of Cases	Time-Limit Used	Form A		Form B	
			Mean	$P.E._M$	Mean	$P.E._M$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
College students	2272	1¾ min.	16.439	0.062	16.303	0.055
College freshmen	1350	2 min.	19.726	0.108	19.748	0.096
High school seniors	2260	2 min.	17.465	0.068	17.479	0.063
5, 6, 7 & 8 grades	1207	2½ min.	14.350	0.088	14.214	0.080
7 and 8 grades	453	2½ min.	15.846	0.150	15.453	0.137
5 and 6 grades	473	2½ min.	10.996	0.130	11.080	0.122

B follows Form A for subjects who have not previously taken these tests. Study of the results secured from the administration of these tests to college students, high school students, and elementary school children shows that Form B is sufficiently more difficult than Form A to just offset whatever practice effects are present. A summary of the detailed comparisons is shown in Table I.

In our first study on the influence of type form we employed the familiar ABBA sequence method because at the outset we had no information regarding equivalence of Forms A and B. The results indicated quite clearly that the two forms are equivalent when B follows A but a striking difference exists when A follows B. Table II gives the facts.

TABLE II

Difficulty of Forms A and B of the Chapman-Cook Speed of Reading Test in Relation to Practice Effects

Note: Differences between the means are always expressed as mean of Form A minus mean of Form B. The ABBA sequence was used in testing.

Form Comparison	Number of Cases	Mean	$P.E._{dist.}$
(1)	(2)	(3)	(4)
A followed by B	320	18.33 17.97	2.78 1.45
B followed by A	320	15.55 19.62	2.15 2.72
All A vs. All B	640	18.98 16.76	2.77 2.51

The data in Table II indicate an actual difference in difficulty between the two forms of about two paragraphs. There is also a definite practice effect of about two paragraphs.

These two factors cancel each other when and only when B follows A. In other words Form B is actually more difficult than Form A but when Form B follows Form A, the practice effect is just sufficient to offset the difficulty factor so that the desired equivalence emerges.

Effect of Sampling Errors on Equivalence

In view of the fact that we generally utilized about 80 students in each sub-group in any given experiment, it is necessary to determine the extent to which equivalence of Forms A and B will be found in a series of groups of 80 students each. In other words, we wish to know whether or not the sampling error will be sufficiently great to upset equivalence in these random groups. This was accomplished by breaking up the group of 1350 college freshmen who had been tested in September, 1928, with the standard Chapman-Cook Speed of Reading Tests into 17 sub-groups of 80 students each. Care was taken to select these sub-groups in a purely random order. Detailed data are presented in Table III.

Our interest centers in the magnitude of the differences between the means shown in column 6. It will be observed that the differences range from $-.45$ to $+.50$. In other words the maximum difference between the means of Forms A and B in any sub-group is one-half a paragraph (sub-group no. 17). The magnitude of these differences expressed as a percentage ranges from 0.4 per cent to 2.79 per cent. In no sub-group do we find $\frac{D}{P.E._{diff.}}$ exceeding a ratio of 2.4. In other words, these 17 sub-groups reveal a series of small differences between means which are well within the limits of variation to be expected from the operation of a large number of uncorrelated chance factors. It is to be noted that differences in mean reading performance in either Form A or Form B between sub-groups are much larger. For example, the mean performance on Form A of

TABLE III

Study of Random Samples of 80 Each, Drawn from Freshman Testing, September, 1928. Chapman-Cook Speed of Reading Tests, Time Limit, 2 Minutes

Group Number	Form A		Form B		Difference M_B-M_A		r	$\frac{D}{P.E._{diff.}}$
	$Mean_A$	$P.E._M$	$Mean_B$	$P.E._M$	Paragraph	Per Cent		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	19.7*	.47	19.9	.43	.13	.63	.87	.54
2	21.0	.41	21.3	.39	.29	1.37	.89	1.51
3	19.7	.42	20.1	.34	.46	2.35	.90	2.40
4	20.2	.36	20.1	.33	−.09	−.43	.71	.33
5	20.6	.39	20.5	.38	−.11	−.55	.83	.50
6	20.3	.45	19.9	.41	−.33	−1.60	.61	.85
7	19.8	.40	19.7	.38	−.16	−.82	.80	.65
8	19.6	.54	19.1	.45	−.45	−2.30	.89	1.82
9	19.7	.40	20.1	.37	.41	2.09	.78	1.61
10	17.9	.47	18.0	.40	.14	.77	.75	.44
11	18.8	.49	19.0	.41	.13	.66	.80	.42
12	19.4	.45	19.1	.42	−.26	−1.35	.85	.11
13	19.7	.46	19.8	.39	.13	.63	.80	.45
14	20.6	.39	20.5	.36	−.09	−.42	.84	.41
15	20.9	.41	20.6	.38	−.36	−1.73	.85	1.66
16	19.3	.48	19.4	.39	.11	.58	.82	.41
17	17.9	.47	18.4	.38	.50	2.79	.76	1.65
All	19.7	.11	19.7	.09	.02	.11	.81	.35

* Original computations carried to 3 or 4 decimal places are abbreviated in above table for convenience.

sub-group 10 is 17.9 whereas the mean performance of sub-group 2 is 21.0, a difference of 3.1 paragraphs. Interest in our typography studies is always directed toward the differences between performance on Forms A and B within a sub-group and not on differences between sub-groups in mean performance on Form A or on Form B. Fortunately the differences we are interested in are quite small so far as the sampling error is concerned. This being so it becomes possible for us to introduce typographical changes in Form B

as compared with Form A, and obtain a direct measure of the effect of the typographical change on speed of reading so far as sampling errors are concerned.

Effect of Practice on Equivalence

It so happened that the Chapman-Cook tests were being used at Minnesota experimentally for a year or so in the guidance testing program and also in the freshman How-to-Study course. In one of our early studies we obtained data from sophomore students, many of whom had taken the tests as high school seniors or as college freshmen. In this study the previously established equivalence of Forms A and B failed to appear and, hence, we did not hesitate to discard these results from our series of studies on typographical factors. The analysis of the factors responsible for this lack of equivalence revealed that previous exposure to the tests destroys the equivalence which is present when subjects take the tests for the first time. For this reason care was taken in all subsequent studies to test groups of students only in case they had not previously been exposed to these tests. Furthermore, at the conclusion of each experiment, students were instructed to indicate on their blanks whether or not they had taken this speed of reading test before. Whenever the answer was "Yes" we automatically eliminated that student's test paper from further consideration. In this way we have been able to insure, within the limits of sampling errors, equivalence in difficulty of Forms A and B in all of our investigations.

Objective Checks on Comprehension

The Chapman-Cook tests are also admirably suited to our purposes because the testing technique employed provides an *objective check* on comprehension so that the total amount read within a given time limit may be ascertained with little error. This technique consists of presenting paragraphs in

each of which one word spoils the meaning. This wrong word always occurs in the second half of the paragraph and is wrong because it is not in harmony with the meaning of the paragraph as a whole, but is not out of harmony with the meaning of the second half of the paragraph. For example:

When I am enjoying anything very much, time seems to go very quickly. I noticed this the other day, when I spent the whole afternoon reading a very uninteresting book.

Presumably one cannot underline or cross out the incorrect word in each paragraph under test conditions without actually reading and comprehending the whole paragraph, hence the underlinings serve as an ingenious device for objectively checking the amount read. On the other hand, it is probably true that a subject could puzzle out the wrong word without reading the entire paragraph but it is doubtful if this type of reading performance could be maintained at a high rate of speed. As a matter of fact, we presented the test with the first half of each paragraph missing to a group of 42 college students and instructed them to identify, if possible, the wrong word in each paragraph as rapidly as possible. The time required to complete all 30 mutilated paragraphs in Form A was taken and the accuracy for each paragraph was computed. The results show that the paragraphs differ greatly with respect to ease of guessing the wrong word. For some paragraphs it was almost impossible, whereas in a few instances the guessing could be done correctly. In any event, the time required to read the thirty half-paragraphs was greatly increased. Under ordinary test conditions the typical college student reads the test at a rate of 5.4 words per second, whereas under these special conditions the rate is only 1.8 words per second. These data suggest that attempts to "beat the game" by skimming the paragraphs will retard rather than facilitate the reading performance under the test

conditions employed in our investigations. Hence, the cross-out technique seems adequate.

The Six Printing Unit Arrangement

As printed, the Chapman-Cook test consists of 30 short paragraphs of 30 words each. For many of our typographical arrangements, these paragraphs are too short to give more than one or two lines of print. Hence, it seemed highly desirable to re-arrange the form of the test so that longer sections of reading material could be grouped more nearly to approximate the paragraph arrangement in ordinary printing. This was done by combining five Chapman-Cook paragraphs into one printing unit having the external form of an ordinary paragraph as shown below:

Original Form of Test

1. There was not a drop of ink in the house, for someone had broken the bottle we kept it in, so Mary decided to finish her letter with a pen.
2. Yesterday I went down town to buy some shoes and rubbers, but when I got home, I found I had forgotten to go to the flower-store to get them.
3. The water had frozen, making the road as slippery as glass. It was only with the greatest difficulty that I prevented myself from fighting as I made my way home.
4. I was not in time for school, because I played marbles on the way; so the teacher sent a note to my parents saying I had been early that morning.
5. One of the boys was extremely rude to the teacher so she made him come and stand by her desk, to show that he had been a very good boy.
6. When I am enjoying anything very much, time seems to go very quickly. I noticed this the other day, when I spent the whole afternoon reading a very uninteresting book.

Re-arranged Form of Test

1. There was not a drop of ink in the house, for someone had broken the bottle we kept it in, so Mary decided to finish

her letter with a pen. 2. Yesterday I went down town to buy some shoes and rubbers, but when I got home, I found I had forgotten to go to the flower-store to get them. 3. The water had frozen, making the road as slippery as glass. It was only with the greatest difficulty that I prevented myself from fighting as I made my way home. 4. I was not in time for school, because I played marbles on the way; so the teacher sent a note to my parents, saying I had been early that morning. 5. One of the boys was extremely rude to the teacher so she made him come and stand by her desk, to show that he had been a very good boy. 6. When I am enjoying anything very much, time seems to go very quickly. I noticed this the other day, when I spent the whole afternoon reading a very uninteresting book.

The re-arranged form is called the six printing unit arrangement and was used for the majority of our studies. Before this arrangement was adopted, a special experiment was undertaken the results of which indicated that the equiva-

TABLE IV

Difficulty of Forms A and B of the Chapman-Cook Speed of Reading Test in Relation to Thirty Paragraph Printing Arrangement Versus Six Printing Unit Arrangement. N = 90 in Each Test Group

Test Group	Test Form	Mean	$P.E._M$	Difference between Means in Paragraphs	Difference between Means in Per Cent	r	$\frac{D}{P.E._{diff.}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I	A, 30 paragraph arrangement	19.200	.3338	−.511	2.661	.88	3.09
	B, 30 paragraph arrangement	18.689	.3281				
II	A, 6 print. unit arrangement	17.500	.3515	.133	.760	.83	.068
	B, 6 print. unit arrangement	17.633	.3063				

lence of Forms A and B was not affected, reliability was maintained, and rate of reading was slightly retarded. The results are shown in Table IV.

Time-Limits and Testing Procedure

The time-limit specified by Chapman-Cook is 2½ minutes for each form when the tests are given at the elementary school level. For college students such a time-limit would result in too many "perfect" scores, so we reduced the time to 1¾ minutes, a figure that subsequently proved to be admirably suited for our subjects. With this reduced time-limit, "perfect" scores seldom occurred. When "perfect" scores in either Form A or Form B did occur, these cases were automatically eliminated from the experimental data.

In testing a class, adequate fore-exercise is provided by means of a directions and practice sheet as shown in Plate I. The practice page and the two tests are stapled together in the upper left corner as a booklet. The practice page and Form A are arranged face up whereas Form B is face down so as to avoid any tendency to glance at Form B before directions to read it are given. While the test blanks are being passed out to members of the class the examiner makes the following preliminary statement: "We are asking you to cooperate in an experimental study on certain phases of reading. The two brief tests we will give you are designed to measure speed of reading. Since speed of reading is very important in the quick preparation of lessons and other kinds of reading, you will be interested to learn how rapidly you can read in comparison with other students. Your papers will be scored and a report prepared for your instructor so that each one of you can find out how you stand." The students are warned not to turn any pages until told to do so. The examiner then says, "Sign your name on the practice page and then read the directions silently while I read them out loud." The examiner then reads material on the practice page, down

Speed of Reading Test–Preliminary Drill

Name____________________________________

In the second half of each of the following, one word spoils the meaning of the section. Find this word as quickly as you can, and cross it out. You must not write anything. Cross out the word that should not be there. In the first section you can see the word "thinnest" does not fit with the meaning of the rest of the following section.

It was such a cold, boisterous, and wintry day that every person who was walking wore the thinnest clothes that he could find in his clothes-closet at the time.

You will now take your pencil and draw a line through the word "thinnest."

In the next section, "nail" is wrong; you must, therefore, cross it out.

There was a fire last night, and five houses were burned to the ground. It all happened because someone was careless and threw a nail into the waste-paper basket.

Now cross out the one word which should not be there in the six numbered sections below. After you have done them, I will go over them orally to be sure that each one of you understands.

1. There was not a drop of ink in the house, for someone had broken the bottle we kept it in, so Mary decided to finish her letter with a pen. 2. Yesterday I went down town to buy some shoes and rubbers, but, when I got home, I found I had forgotten to go to the flower-store to get them. 3. The water had frozen, making the road as slippery as glass. It was only with the greatest difficulty that I prevented myself from fighting as I made my way home. 4. I was not in time for school, because I played marbles on the way; so the teacher sent a note to my parents, saying I had been early that morning. 5. One of the boys was extremely rude to the teacher so she made him come and stand by her desk, to show that he had been a very good boy.

6. When I am enjoying anything very much, time seems to go very quickly. I noticed this the other day, when I spent the whole afternoon reading a very uninteresting book.

On the next page, that is, the one directly underneath this practice page, there are thirty numbered sections like the ones you have done. When you are given the signal, and not before, turn this practice page over, and cross out in the second part of each numbered section the one word which should not be there. Ask no questions. Do not stay too long on any one section, but go to the next. There are five numbered sections in each paragraph. Remember you do no writing; you merely cross out the one word in the second part of each numbered section.

This is a test for speed and accuracy. Be sure to work as fast as you can yet not make mistakes.

Do not turn this page until you are told to do so.

to the beginning of the six practice sections. Time is allowed for all students to complete the practice exercises and then the class recites in unison the wrong word in each of the six practice sections. The examiner now reads the remaining directions on the practice page and then says: "When I say 'Go' turn up the practice page and work on the thirty sections on the next page. Ready, go!" At the end of exactly one and three-quarters minutes the examiner says, "Stop, turn back to the practice page." When this has been done, the examiner says, "When I say 'Go' turn your whole test booklet entirely over and do the thirty sections on the back side. Ready, go!" After one and three-quarters minutes have elapsed the examiner announces, "Stop, turn back to the practice page and write the date at the top of the page. If you have taken this test before write 'Yes' after the date, if you have never taken this test before, write 'No.' Now pass the tests to the aisle as rapidly as possible."

It will be noted that the directions call for turning up the practice page, etc., and also for turning over the whole test booklet. This procedure was adopted because of the way the practice page and the two test forms were stapled.

In conducting any one study, the test booklets for the different typographical variations were arranged systematically so that for any one class, the same number of blanks for each variation was used. Thus any unusual condition with respect to lighting, timing, motivation, and the like which might occur in any one class would have the same effect on all variations compared.

It will be noted that the specific purpose of the tests was not announced. The students were induced to compete with each other by promising to inform them of their standings. In this way we avoided the possibility that students would prejudge the effect of a particular typography and perform in accordance with their pre-conceptions. Furthermore, the systematic distribution of all variations to each class precluded the possibility of the examiner giving any hint as to

what sort of reading performance might be expected from any particular typographical arrangement. In all of the testing stress was uniformly placed on speed and accuracy of reading both test forms.

Scoring of the test blanks was greatly facilitated by merely noting the total number of paragraphs marked after making sure in each case that the directions were fully understood. This simplified scoring is justified because, as previously shown, students perform the test with such a high degree of accuracy. When errors do occur it would appear that they are "careless" errors, the paragraphs actually having been read. Thus our interest in "amount read per unit of time" is best served by scoring the total number of sections attempted.

Records were discarded for individual students only when one of two things happened: (1) low scores accompanied by evidence on the practice page that the student misunderstood the nature of the test, and (2) perfect scores showing that the student completed a test before the time limit was up. In both cases, such records would decrease the accuracy with which the efficiency of the several typographical factors can be judged. Discarding records in this manner occurred in less than one per cent of the total number tested.

Additional test blanks, however, were sometimes discarded in order to maintain the same number of cases in each test group for any given study. These eliminations, few in number, were always made on the basis of chance. For example, if a study required four test groups and the numbers tested happened to be 83, 86, 80 and 88, we eliminated on a chance basis, 3 records from the first group, 6 from the second, none from the third, and 8 from the fourth.

In studies of typographical factors, enough reading material should be employed to permit an adequate sampling of each individual's reading performance. Under these conditions, the reading scores will be sufficiently reliable in the technical sense of "test reliability" to warrant their use in group comparisons. According to Kelley, the reading tests

should have a reliability of at least +.40 to be used for group comparisons. The reliability of the Chapman-Cook tests far exceeds this requirement. The correlation between the paired scores for Form A and Form B for 2260 Twin City high school seniors was $+0.76 \pm 0.006$. Examination of the tables in this Appendix will show that the reliability coefficients vary for the most part between +.75 and +.90 for college students and also for elementary school children.

In all of our studies the time-limit method of testing was employed. The question as to whether we would have obtained the same results with the work-limit method was put to an experimental test in a special study.[3] In brief, the results show that these two methods of administering the Chapman-Cook tests are interchangeable. A summary of the findings is given in Table V. Since the magnitude of the two intercorrelations approximates that of the reliability coeffi-

TABLE V

Data for Time-Limit and Work-Limit Methods of Administering the Chapman-Cook Speed of Reading Tests to College Students

	Mean	S.D.	Coefficient of Variation	r	N
I. Intercorrelations					
Form A, Time-limit	21.12	5.02	0.24	0.87±0.01	185
Form B, Work-limit	3′8″	50″	0.27		
Form A, Work-limit	2′50″	41″	0.24	0.84±0.01	183
Form B, Time-limit	20.30	4.29	0.21		
II. Reliability Coefficients					
Form A, Work-limit	2′36″	42″	0.27	0.86±0.02	162
Form B, Work-limit	2′48″	46″	0.27		
Form A, Time-limit	19.05	4.34	0.23	0.84±0.01	560
Form B, Time-limit	17.87	3.73	0.21		

[3] D. G. Paterson and M. A. Tinker, "Time-Limit vs. Work-Limit Methods." *Amer. J. Psychol.*, 1930, 42, 101-104.

cients, the true relationship between the two methods approaches unity when a correction for attenuation is made. Hence, our conclusions would hold whether the tests are given with a short time limit or whether the subjects are permitted to complete each test, time being taken as the measure of reading efficiency.

Adequacy of Short Time Limits

In connection with interpretations of our findings it should be noted that our studies are based on relatively short periods of reading. Critics may believe that the significance of any of our results will hold only for short snippets of reading. If this be true, it is obvious that we would not be warranted in generalizing from our results to reading in general. In this case, the significance of our findings would be restricted to those special reading situations in which a page or less is read such as posters, circulars, advertisements and editorials. We have assumed that any measurable effect observed during a brief reading period will be present also during a longer period of reading. Indeed, one might expect a cumulative effect from fatigue induced by a less than optimal typographical arrangement when subjects read such printed material over a longer period of time. In opposition to this view, critics might assert that the retarding effect of poor typography during a brief reading period might disappear as reading is continued over a longer period. These critics would insist that the poor typography retards speed of reading only during a period of initial adaptation. In the following paragraph we present evidence that such a view has no basis in fact. On the other hand, we cannot be certain that two typographical arrangements found by us to be equally efficient for a short period of time would continue to be equally efficient over longer periods of reading.

In order to determine the extent to which a given difference obtained in a 1¾ minute performance would be found in longer periods of reading, we conducted a special experiment.

For this purpose, it was necessary to use a longer reading test so we obtained permission to use E. B. Greene's Michigan Speed of Reading Test, Forms I and II. Each form of Greene's test consists of 100 paragraphs of 30 words each patterned after the Chapman-Cook tests. The paragraphs are slightly more difficult to comprehend so Greene specifies a time-limit of 10 minutes when the tests are given to college students. We decided to compare the reading effectiveness of Scotch Roman versus Cloister Black (Old English) type under three different periods of reading time, namely, 1¾ minutes, 5¾ minutes, and 10 minutes. We had previously ascertained that Cloister Black retards reading 13.6 per cent as compared with Scotch Roman, using the Chapman-Cook tests and a time-limit of 1¾ minutes. Short as well as longer periods of time were employed in this special experiment because we desired to determine whether or not Greene's test would give the same results for these two type faces when the same short time-limit (1¾ minutes) was adopted. The results are shown in Table VI.

For the 1¾ minute time-limit the retarding effect of Cloister Black is 11.6 per cent; for the 5¾ minute time-limit it is 12.4 per cent; and for the 10 minute period it is 14.1 per cent. It is clear that the initial retarding effect persists, in fact the effect appears to increase, as the reading periods are increased. This objective evidence leads us to emphasize the significance of whatever differences are disclosed in our various experiments.

The Question of "Set"

Several persons who have reviewed the evidence secured in our series of studies on typography have been disturbed by the fact that, generally speaking, our subjects tend to make lower scores on Form B of the Chapman-Cook Speed of Reading Tests than on Form A when typography differed from the "standard." Ample evidence has been presented showing that Forms A and B are equivalent in difficulty when

TABLE VI

Relative Efficiency of Scotch Roman and Cloister Black Type Faces in Relation to Length of Reading Time

Note: The Michigan Speed of Reading Test devised by E. B. Greene was used and printed as follows: in either Scotch Roman or Cloister Black as indicated in the table, all forms being set in 10 point, 19 pica line width set solid on eggshell paper stock.

Test Group	Test Form and Type Face	Mean	$P.E._M$	Difference between Corrected Means* in Paragraphs	Difference between Corrected Means* in Per Cent		$\frac{D}{P.E._{diff.}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Time limit = 10 minutes. N = 94 in each test group							
I	A, Scotch Roman	66.07	.78	0.00	0.0	.90	.....
	B, Scotch Roman	68.38	.94				
II	A, Scotch Roman	63.75	.76	−8.96	14.1	.83	19.91
	B, Cloister Black	57.10	.78				
Time limit = 5¾ minutes. N = 91 in each test group							
I	A, Scotch Roman	56.53	.76	0.00	0.0	.86	.....
	B, Scotch Roman	55.02	.76				
II	A, Scotch Roman	59.18	.61	−7.35	12.4	.77	17.09
	B, Cloister Black	50.32	.64				
Time limit = 1¾ minutes. N = 80 in each test group							
I	A, Scotch Roman	16.89	.24	0.00	0.0	.65	.....
	B, Scotch Roman	17.43	.23				
II	A, Scotch Roman	16.06	.30	−1.86	11.6	.76	9.30
	B, Cloister Black	14.74	.26				

* The difference between the means for Scotch Roman and Cloister Black in each case is corrected by the amount of the difference between the means of their respective control groups.

printed alike and B follows A. Hence, we conclude that lower mean scores in B must be attributed to typographical variations introduced in Form B as compared with the standard arrangement in Form A (Scotch Roman, 10 point, 19 pica line width, set solid). In spite of this evidence, critics

may suggest that "mental set" is responsible, in part, for the lower scores in Form B. In other words, the "set" developed in reading the standard Form A arrangement may be disturbed when subjects are required to shift to a changed typography in Form B. Thus, critics might assert that the lower scores in Form B may be due either to less effective typography or to "set" or to both. The validity of our conclusions concerning various typographical factors would remain in doubt unless adequate evidence is adduced to demonstrate that "set" has not been operative.

A special study was conducted to measure the influence of this hypothetical factor of "set." As in the special study on different time-limits, we used the Scotch Roman versus Cloister Black set-up. Our original study required the subjects to read Scotch Roman type in Form A and then to read Cloister Black in Form B. The present special study reversed the order, requiring the subject to read Cloister Black in Form A and then to read Scotch Roman in Form B. In both studies a control group was employed: in the former study Forms A and B were set up in Scotch Roman; in the present study Forms A and B were set up in Cloister Black. If the 13.6 per cent loss in speed of reading Cloister Black as compared with Scotch Roman previously ascertained fails to be confirmed in the present special study then presumably the former difference must be attributed in part to "set." On the other hand, if approximately the same loss is disclosed in the present study in spite of the reversal in order of presentation, then the difference found in both instances must be attributed to type face and not to "set."

Table VII presents the detailed data for the two comparisons, namely the control group (Test Group I) and the experimental group (Test Group II). Results for Test Group I show that the two forms are equivalent even though both are printed in Cloister Black. In other words, equivalence in difficulty of Forms A and B is again established and presumably would prevail for other typographical arrangements.

TABLE VII

Difficulty of Forms A and B of the Chapman-Cook Speed of Reading Test in Relation to the Factor of "Mental Set"

Differences given are for the mean score on Form A, 10 point, 19 pica line width, set solid, Cloister Black minus the mean score on Form B, 10 point, 19 pica line width, set solid, but varying with respect to style of type face as indicated in column 2. All test forms were printed on eggshell paper stock. In each test group, N = 100 college students in freshman English courses.

Test Group	Test Form and Type Face	Mean	$P.E._M$	Differences between Corrected Means in		r	$\frac{D}{P.E._{diff.}}$
				Paragraphs	Per Cent		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
I	A, Cloister Black	14.00	.26	0.00	0.00	.89	.....
	B, Cloister Black	14.29	.25				
II	A, Cloister Black	13.88	.24	−2.35	14.20	.82	17.04
	B, Scotch Roman	16.52	.27				

The crucial comparison for Test Group II shows that Cloister Black is read 14.2 per cent slower than Scotch Roman. The former study showed that Cloister Black is read 13.6 per cent slower than Scotch Roman. Both studies, therefore, are in surprising agreement! Thus, the evidence is clear that our methodology measures the influence of typographical factors in a straight-forward manner uncomplicated by "mental set." Furthermore, the method yields comparable results whether the optimal printing arrangement is presented in Form A or in Form B.

Statistical Methods

Table VI may be taken as a sample of our method of summarizing the detailed statistical comparisons. To make certain that this basic method of comparison is thoroughly understood, we propose to describe all of the steps leading up to the summarization.

Table VIII

Actual Scores Made by 100 College Students in Forms A and B of the Chapman-Cook Speed of Reading Test in the Study of "Mental Set" with Identical Typography

Note: Forms A and B were printed as follows: six printing unit arrangement, Cloister Black type face, 10 point type, 19 pica line width, set solid, 8½" x 11" eggshell paper stock. Students numbered 1 to 72 were from University of Minnesota freshman Engineering classes and students 73 to 100 were from the freshman English classes at the College of St. Catherine, St. Paul, Minnesota

Student Number	Score in Form A	Score in Form B	Student Number	Score in Form A	Score in Form B	Student Number	Score in Form A	Score in Form B
Univ. of Minn. Freshman Engrng. English 12-3-34			34	12	14	69	10	11
			35	19	18	70	16	17
1	15	14	36	9	11	71	16	17
2	8	11	37	13	13	72	12	13
3	18	17	38	13	10			
4	16	17	39	17	16	St. Catherine's Freshman English 12-3-34		
5	13	13	40	15	14			
6	13	12	41	14	13			
7	14	14	42	11	13	73	3	4
8	12	14	43	13	12	74	11	13
9	17	14	44	19	17	75	13	13
10	11	10	45	6	7	76	16	20
11	15	14	46	10	10	77	10	13
12	12	12	47	18	17	78	17	17
13	16	14	48	12	11	79	13	15
14	16	14	49	12	13	80	10	9
15	15	15	50	11	11	81	14	18
16	18	18	51	14	14	82	12	14
17	16	15	52	12	9	83	19	20
18	15	16	53	14	13	84	14	16
19	16	15	54	12	10	85	21	20
20	9	9	55	18	13	86	27	25
21	10	10	56	16	15	87	20	16
22	16	15	57	11	15	88	18	17
23	15	16	58	10	8	89	21	21
24	11	12	59	11	12	90	19	20
25	12	13	60	9	10	91	11	13
26	13	14	61	9	10	92	20	22
27	21	21	62	16	18	93	5	8
28	16	15	63	12	13	94	20	20
29	18	16	64	15	15	95	17	15
30	10	12	65	9	10	96	16	18
31	10	10	66	10	14	97	17	16
32	12	14	67	8	9	98	16	19
33	14	15	68	19	21	99	16	19
						100	18	20

Table IX

Actual Scores Made by 100 College Students in Forms A and B of the Chapman-Cook Speed of Reading Test in the Study of "Mental Set" with Variation in Typography

Note: Form A was printed as described in Table VII. Form B was printed with the same printing specification except that Scotch Roman type face was used instead of Cloister Black. Students numbered 1 to 71 were from University of Minnesota freshman Engineering classes, and students 72 to 100 were from the freshman English classes at the College of St. Catherine.

Student Number	Score in Form A	Score in Form B	Student Number	Score in Form A	Score in Form B	Student Number	Score in Form A	Score in Form B
Univ. of Minn. Freshman Engrng. English 12-3-34			34	17	23	69	13	15
			35	9	14	70	11	15
1	12	14	36	14	14	71	16	22
2	9	9	37	12	14			
3	12	16	38	14	15	St. Catherine's Freshman English 12-3-34		
4	14	15	39	15	19			
5	9	10	40	13	16			
6	9	13	41	11	14	72	14	12
7	10	14	42	13	15	73	12	15
8	9	17	43	18	21	74	15	16
9	11	14	44	12	15	75	12	15
10	18	20	45	21	23	76	11	14
11	10	10	46	10	13	77	13	14
12	16	14	47	15	17	78	12	19
13	13	14	48	25	27	79	13	14
14	15	15	49	18	20	80	15	23
15	18	21	50	10	12	81	10	13
16	15	16	51	14	18	82	9	15
17	10	10	52	10	12	83	13	16
18	11	15	53	11	14	84	16	20
19	12	12	54	19	20	85	11	13
20	10	11	55	14	15	86	15	23
21	17	19	56	13	16	87	11	13
22	13	14	57	9	12	88	12	14
23	16	20	58	17	21	89	18	21
24	15	17	59	10	15	90	23	27
25	15	23	60	11	12	91	17	21
26	20	22	61	10	13	92	19	19
27	13	20	62	15	23	93	15	23
28	18	16	63	15	17	94	20	21
29	15	20	64	13	15	95	15	18
30	10	11	65	9	9	96	17	17
31	15	18	66	14	18	97	25	23
32	18	24	67	18	17	98	10	14
33	15	15	68	10	13	99	14	17
						100	19	19

As soon as the papers are scored for a given study, the paired scores (Form A score and Form B score) for each subject are listed on a statistical data sheet. Tables VIII and IX show these data sheets.

The next step involves the computation of means, probable errors of the distribution, and the correlation between Form A scores and Form B scores. All computations were made from the ungrouped data as shown in Tables VIII and IX. Accuracy was attained through the use of an electrical calculator plus a completely independent re-computation of all statistical manipulations. Formulas used are as follows:

$$(1)\quad M = \frac{\Sigma X}{N}$$

$$(2)\quad P.E._{dist.} = .6745\sqrt{\frac{\Sigma X^2}{N} - M^2}$$

$$(3)\quad P.E._{M} = \frac{P.E._{dist.}}{\sqrt{N}}$$

$$(4)\quad r = \frac{\frac{\Sigma X_1 X_2}{N} - M_1 M_2}{\sigma_1 \sigma_2}$$

$$(5)\quad P.E._{diff.} = \sqrt{P.E.^2_{M_1} + P.E.^2_{M_2} - 2\,r\,P.E._{M_1} \cdot P.E._{M_2}}$$

The Use of Control Groups

During the early stages of our investigations we assumed that our evidence regarding equivalence of difficulty of Forms A and B was so conclusive that we could proceed to study any given series of typographical variations without determining equivalence anew in each subsequent experiment. The discovery that equivalence held only in case none of the subjects had previously taken the tests, however, suggested the desirability of making a new determination of equivalence for every new study undertaken. An additional reason for checking repeatedly on this question of equivalence is found in a number of minor disturbing factors likely to be encountered in testing situations. We refer to a possible failure to give

each and every group tested exactly the same number of seconds (105 seconds) working time on Form A and on Form B; or to distractions that might occur in a given group during the reading of Form A or Form B. Unavoidable differences in motivation might also be involved. In testing extremely large groups (100 or more students in a classroom), we noted a tendency on the part of some students to glance at Form A surreptitiously during the practice period, a fact which would tend to destroy equivalence and thus reduce or increase differences between the effectiveness of the typographical variations being studied. Realization of these difficulties prompted us to introduce after the first few studies a "control group" into each new investigation. Thus each new study always included as one test group a set of papers in which Forms A and B were identical in typography. Results for this test group served as a control in regard to identity of examining conditions surrounding the administration of each form of the test. The adoption of this control group technique immediately revealed that far more difficulties are likely to arise in testing large groups than in testing small groups so we abandoned all large class testing. Even when we confined our testing to small classes, however, the results from the control group showed that uniformity of testing conditions for Forms A and B had not always been maintained.

Data for the control groups in 24 experiments are brought together in Table X. We assume that whenever $\frac{D}{P.E._{diff.}}$ is equal to or greater than 4.00, equivalence between Forms A and B has been upset by some uncontrolled factor or factors in the experimental situation. These values are given in column 9. In seven instances the value exceeds 4.00; in nine instances the value falls between 1.00 and 4.00. These high values are in sharp contrast to the values shown in column 9 of Table III. A detailed study, therefore, of Tables III and X clearly indicates that the lack of equivalence found in our control groups is not due to mere sampling errors, but is due

TABLE X

Study of Random Samples of 80–176 Each (Control Groups in Typography Studies). College Students. Chapman-Cook Speed of Reading Tests. Time-Limit, 1¾ Minutes

Group Number	Form A		Form B		Difference M_B–M_A		r	$\frac{D}{P.E._{diff.}}$	N
	$Mean_A$	$P.E._M$	$Mean_B$	$P.E._M$	Paragraphs	Per Cent			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	19.1*	.27	18.4	.24	−.71	−3.72	.84	4.77	90
2	15.3	.29	16.4	.25	1.05	6.88	.81	6.24	93
3	18.4	.22	17.9	.19	−.55	−2.99	.81	4.55	176
4	20.3	.31	19.7	.26	−.59	−2.90	.85	3.52	80
5	17.0	.32	17.2	.27	.20	1.18	.85	1.18	95
6	16.7	.21	16.1	.18	−.59	−3.54	.78	4.45	140
7	14.6	.31	14.7	.29	.12	.83	.86	.77	90
8	17.1	.28	17.1	.21	−.01	−.07	.79	.04	85
9	14.0	.26	14.3	.25	.29	2.07	.89	2.44	100
10	16.1	.25	16.2	.25	.08	.52	.85	.60	95
11	16.3	.33	16.4	.30	.18	1.08	.84	.97	85
12	18.5	.29	17.9	.27	−.61	−3.30	.88	4.41	100
13	15.6	.30	15.8	.23	.20	1.30	.77	1.04	84
14	17.6	.33	17.7	.29	.07	.42	.87	.45	95
15	15.3	.28	15.6	.26	.34	2.23	.85	2.24	100
16	15.4	.33	15.7	.27	.31	1.98	.90	2.14	85
17	14.6	.27	14.7	.24	.06	.43	.76	.35	95
18	16.2	.34	16.0	.28	−.15	−.93	.86	.87	80
19	16.3	.29	15.2	.25	−1.14	−7.00	.80	6.53	84
20	15.1	.28	15.5	.25	.39	2.57	.86	2.69	80
21	15.9	.28	16.1	.26	.21	1.34	.85	1.45	80
22	15.9	.28	15.3	.30	−.60	−3.77	.84	3.62	85
23	16.7	.30	15.4	.24	−1.31	−7.80	.84	7.99	95
24	14.6	.28	14.7	.29	.11	.77	.83	.68	80
All	16.4	.06	16.3	.05	−.14	−.83	.85	4.30	2272

* Original computations carried to 3 or 4 decimal places are abbreviated in above table for convenience.

to some lack of uniformity in testing conditions. Thus the utilization of control groups in each of our experiments is shown to have been essential.

Data for the control groups in our experiments with school

children show the same lack of equivalence under the conditions of our experimentation. See Table XI.

TABLE XI

Study of Random Samples of 84 to 100 Each (Control Groups in Typography Studies). Groups 1 to 6, 5th and 6th Grades; Groups 7 to 13, 7th and 8th Grades. Chapman-Cook Speed of Reading Tests. Time-Limit 2½ Minutes

Group Number	Form A		Form B		Difference M_B-M_A				
	Mean_A	$P.E._M$	Mean_B	$P.E._M$	Paragraphs	Per Cent	r	$\frac{D}{P.E._{diff.}}$	N
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	12.3*	.24	12.4	.22	.08	.65	.87	.67	100
2	12.1	.28	12.5	.27	.46	3.81	.90	3.73	100
3	11.9	.25	11.7	.23	−.17	−1.42	.81	1.12	95
4	10.9	.30	10.9	.29	−.01	−.10	.92	.09	90
5	11.8	.30	11.9	.27	.05	.44	.87	.36	95
6	11.9	.27	12.2	.26	.27	2.24	.90	2.27	94
7	17.1	.32	16.8	.31	−.33	−1.93	.90	2.37	100
8	16.4	.33	16.2	.30	−.20	−1.22	.87	1.23	100
9	15.4	.37	15.3	.35	−.13	−.85	.83	.62	84
10	15.5	.32	15.1	.28	−.41	−2.65	.89	2.89	90
11	16.8	.32	15.5	.29	−1.37	−8.13	.84	7.93	95
12	16.3	.36	15.4	.33	−.83	−5.10	.84	4.19	94
13	15.1	.30	16.0	.28	.87	5.74	.78	4.45	90
All	14.4	.09	14.2	.08	−.14	−.95	.87	2.97	1207

* Original computations carried to 3 or 4 decimal places are abbreviated in above table for convenience.

When the control groups showed a lack of uniformity in testing conditions, it was not necessary to discard the obtained data since the control group data furnished a measure of the deviation produced by the disturbing factors. Hence this measure could be used to correct the mean scores on Form B for each of the test groups in a given study. This correction technique would appear logically to be entirely adequate for the type of investigation with which we are concerned. An empirical verification of the soundness of the procedure is

possible because we can observe its effect on a given typographical arrangement determined under three different experimental conditions. We refer to three experiments in which the speed of reading Cloister Black is compared with the speed of reading Scotch Roman type. If the correction technique is sound, then the three experimental determinations of the relative superiority of Scotch Roman should yield more uniform results when corrections are applied than when the uncorrected differences are compared. The results with and without the correction technique are shown in Table XII.

TABLE XII

Retardation in Reading Cloister Black Type Versus Scotch Roman Type as Measured With and Without the Correction Technique

(College Students Were Used as Subjects)

Study	Test Form and Type Face	Mean	Uncorrected Difference in Per Cent	Corrected Difference in Per Cent
(1)	(2)	(3)	(4)	(5)
I (Type Face)	A, Scotch Roman B, Cloister Black	18.51 15.28	17.5	13.6
II (Set)	A, Cloister Black B, Scotch Roman	13.88 16.52	15.9	14.2
III, A (1¾ min.)	A, Scotch Roman B, Cloister Black	16.06 14.74	8.2	11.6
III, B (5¾ min.)	A, Scotch Roman B, Cloister Black	59.18 50.32	15.0	12.4
III, C (10 min.)	A, Scotch Roman B, Cloister Black	63.75 57.10	10.4	14.1

Uncorrected differences favoring Scotch Roman vary from 8.2 per cent to 17.5 per cent. Corrected differences are far more uniform, however, ranging between 11.6 per cent and 14.2 per cent. We conclude, therefore, that the corrections based upon control groups in our various experiments are fully justified.

A careful study of the detailed tables of results will reveal considerable variation, in a given experiment, in the mean score on Form A for the different sub-groups although Form A is printed in a uniform manner for each of the sub-groups. We believe these differences in mean performance are due merely to sampling errors. Some critics might believe that these differences would affect the typographical comparisons involved in any one study. Evidence exists, however, showing that a given difference between two typographical arrangements will appear regardless of these minor variations in the level of mean performance of the sub-groups. Even a striking difference in level of mean performance will not change the results. For example, data obtained from university sophomores showed that Cloister Black retards speed of reading 13.6 per cent when compared with Scotch Roman whereas tests of college freshmen whose mean performance is on a distinctly lower level showed approximately the same retarding effect for Cloister Black as compared with Scotch Roman. The following figures are pertinent:

Type Face	Sophomores Mean Score	Freshmen Mean Score
Scotch Roman	18.51	16.52
Cloister Black	15.99	13.88
Difference	2.52	2.64

Other evidence from the Minnesota Laboratory dealing with legibility of type faces as measured by the distance method confirms this principle.[4]

Type Face	Group I Mean Distance	Group II Mean Distance
Scotch Roman	148.87 cm.	140.25 cm.
Cheltenham	171.06 cm.	162.87 cm.
Difference	22.19 cm.	22.62 cm.

The foregoing detailed description of our methodology has

[4] H. A. Webster and M. A. Tinker, "The Influence of Type Face on the Legibility of Print." *J. Appl. Psychol.*, 1935, 19, 43-52.

been presented to accomplish two ends, namely, (1) to permit other investigators to duplicate our methods in order to verify any of our findings or to investigate typographical factors not covered by our studies, and (2) to present evidence that the methods adopted by us are suited to the purpose of determining the relative efficiency of various typographical arrangements. Throughout, we have endeavored to conduct all our studies in an objective manner to the end that we might contribute "facts rather than opinions" to present-day knowledge of typography.

Appendix II

Tables of detailed results listed below are available as ADI Documents in the form of microfilm (images one inch high) on standard 35 mm. motion picture film, or photoprints (6 x 8 inches in size) readable with unaided eyes. For detailed information write American Documentation Institute, Offices of Science Service, 2101 Constitution Avenue, Washington, D. C. To secure detailed tables order Document 1429 remitting 75 cents for microfilm form or $5.50 for photocopies readable without optical aid.

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Appendix III

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Appendix IV

Conversion Table for Printing Measurements

Note: This table has been prepared to permit the reader to interpret picas in terms of inches and millimeters or vice versa.

Picas	Inches	MM	Picas	Inches	MM
10	1 21/32	42.5	28	4 21/32	118.0
11	1 27/32	46.5	29	4 27/32	122.0
12	2	50.5	30	5	126.5
13	2 5/32	55.0	31	5 5/32	131.0
14	2 11/32	59.0	32	5 11/32	135.0
15	2 16/32	63.0	33	5 16/32	139.0
16	2 21/32	67.5	34	5 21/32	143.5
17	2 27/32	72.0	35	5 27/32	147.5
18	3	76.0	36	6	152.0
19	3 5/32	80.0	37	6 5/31	156.5
20	3 11/32	84.5	38	6 11/32	160.5
21	3 16/32	89.0	39	6 16/32	164.5
22	3 21/32	93.0	40	6 21/32	168.5
23	3 27/32	97.0	41	6 27/32	173.0
24	4	101.5	42	7	177.5
25	4 5/32	106.0	43	7 5/31	182.0
26	4 11/32	110.0	44	7 11/32	186.0
27	4 16/32	114.0	45	7 16/32	190.5

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